Dynamics of Intraindividual Variability in Everyday Life Affect Across Adulthood and Old Age

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Marko Katana

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Prof. Dr. Mathias Allemand (main supervisor)
Prof. Dr. Mike Martin
Prof. Dr. Lutz Jäncke

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Abstract

The ups and downs of affect are a significant part of our everyday lives and have been linked to healthy aging outcomes. This dissertation developed a theoretical framework to better describe and understand intraindividual variability in affect across adulthood and old age. The affect variability in everyday life (AVEL) framework posits three main assumptions. First, everyday life affect is shaped by individual trait characteristics. Second, affect is highly context-dependent and therefore co-varies with a number of situation-based correlates. Third, the adaptivity of fluctuations in affect depends on the timescale of measurement. To test these three main assumptions of the framework, real-world data in form of daily diaries, smartphone studies and data gained from wearable sensors were analyzed from six studies and summarized in five articles. These studies assessed everyday life affect on multiple timescales, in different age ranges and in different real-world contexts. Article 1 showed that trait forgivingness is associated with daily affect and that older adults opposed to younger adults have a stronger association between trait forgivingness and daily negative affect. Article 2 and 3 showed that the ebb and flow of affect is in concert with intraindividual variability in cognitive functioning. More specifically, these studies tested cognitive reflection processes in everyday life rather than using laboratory tasks of maximal cognitive performance. Cognitive reflection processes were conceptualized by examples of how individuals think about their future and how they process emotionally taxing situations. Occasions with a more limited future time perspective and more use of cognitive reappraisal were also occasions with higher positive and lower negative affect. Article 4 and 5 investigated how physical functioning are related to intraindividual variability of affect in everyday life. Results showed that occasions with less physical pain and more physical activity were associated with occasions of higher positive affect, less negative affect, and less depressive mood. Lastly, a methodological question investigated differences in the

interpretation of (in)stability of affect across different timescales. This question was addressed by using insights from all five articles together. Stability of affect over a longer period of time can be seen as a sign of good psychological functioning, whereas instability or variability of affect can be seen as adaptive over shorter time periods when adjusting to situational change. This thesis suggests future directions in the field by developing new measurement methods to adequately capture fluctuations in affect both based on self-report but also by means of indicators of wearable sensors. With the help of valid and reliable short-items scales combined with objective information about the context, intraindividual variability of affect can be studied with greater detail. Future studies should aim at using even more individualized data sampling approaches to make accurate predictions about promoting high functional ability and affect both in the short term and the long term.

Zusammenfassung

Die Höhen und Tiefen von Affekt sind ein wesentlicher Bestandteil unseres täglichen Lebens und wurden mit gesunden Alterungsprozessen in Verbindung gebracht. Diese Dissertation entwickelte einen theoretischen Rahmen, um die intraindividuelle Variabilität von Affekt über die erwachsene Lebensspanne und das hohe Alter hinweg besser beschreiben und verstehen zu können. Das Modell der Affektvariabilität im Alltag stellt drei Hauptannahmen auf. Erstens ist das Erleben von Affekt im Alltag von interindividuellen Unterschieden geprägt. Zweitens ist Affekt stark kontextabhängig und variiert daher mit einer Vielzahl von situationsbedingten Korrelaten. Drittens hängt die Anpassungsfähigkeit der Schwankungen von Affekt von der Zeitspanne der Messung ab. Um diese drei Hauptannahmen des Modells zu testen, wurden Daten von elektronischen Tagebüchern, Smartphone-Studien und von tragbaren Sensoren in sechs Studien analysiert und in fünf Artikeln zusammengefasst. Diese Studien untersuchten Affekt im Alltag anhand unterschiedlicher Zeitskalen, in unterschiedlichen Altersgruppen sowie in unterschiedlichen Kontexten. Artikel 1 zeigte, dass Verzeihensbereitschaft mit täglichem Affekt verbunden ist und dass ältere Erwachsene im Gegensatz zu jüngeren Erwachsenen einen stärkeren Zusammenhang zwischen Verzeihensbereitschaft und täglichem negativen Affekt haben. Die Artikel 2 und 3 zeigten, dass die Fluktuationen von Affekt mit der intraindividuellen Variabilität von kognitiven Prozessen zusammenhängen. Konkret wurden in diesen Studien kognitive Reflexionsprozesse im Alltag erprobt und nicht Laboraufgaben eingesetzt, in welchen die maximale kognitive Leistungsfähigkeit getestet wird. Kognitive Reflexionsprozesse sind beispielsweise die Art und Weise wie Individuen über ihre Zukunft denken und wie sie emotional belastende Situationen verarbeiten. Die Ergebnisse zeigen, dass Tage mit einer begrenzteren Zukunftsperspektive und einer stärkeren kognitiven Umbewertung auch Tage mit höherem positiven und niedrigerem negativen Affekt waren.

In den Artikeln 4 und 5 wurde untersucht, inwiefern physische Funktionalität mit der intraindividuellen Variabilität von Affekt im Alltag zusammenhängen. Die Ergebnisse zeigten, dass Tage mit weniger physischen Schmerzen und mehr physischer Aktivität auch Tage mit höherem positiven Affekt, niedrigerem negativen Affekt und weniger depressiver Stimmung waren. Schliesslich untersuchte eine methodische Frage Unterschiede in der Interpretation von (In-)Stabilität von Affekt über verschiedene Zeitskalen hinweg. Die Beantwortung dieser Frage erfolgte basierend auf den Erkenntnissen aller fünf Artikeln. Die Stabilität des Affekts über einen längeren Zeitraum ist ein Zeichen für ein gutes psychologisches Funktionieren, während die Instabilität oder Variabilität des Affekts über kürzere Zeiträume als adaptiv gesehen werden können, wenn man sich an situative Veränderungen anpasst. Zukünftige Forschung sollte verstärkt auf die Entwicklung neuer Messmethoden zur angemessenen Erfassung von Schwankungen im Affekt setzen, die sowohl Daten von Selbstberichten wie auch von tragbaren Sensoren berücksichtigen. Die Kombination von validen und zuverlässigen Kurzzeitskalen und von objektiven Information über den Kontext sollen es ermöglichen, die intraindividuelle Variabilität des Affekts noch genauer zu untersuchen. Zukünftige Studien sollten darauf abzielen, mit individualisierteren Datenerhebungsansätzen genauere Vorhersagen über die Förderung der Funktionsfähigkeit und über das Erhalten von positivem Affekt sowohl kurz- als auch langfristig zu ermöglichen.

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Chapter 1

Introduction

Maintenance of subjective well-being is a core goal of emotional aging research (Scheibe & Carstensen, 2010). With rising life expectancy, the importance of healthy aging and preserving health and well-being in older age has become increasingly relevant. Aging research and lifespan psychology have struggled to find a commonly accepted set of criteria to define healthy aging. One prominent definition posits that healthy aging can be seen as an overlap between avoiding disease and disability, engagement with life, and high cognitive and physical functioning (Rowe & Kahn, 1997). Most lifespan theories focus on maintaining well-being by selectively choosing adequate contexts, optimizing available resources and compensating for age-related losses when cognitive and physical functioning allow it (Baltes, Staudinger, & Lindenberger, 1999). In other words, individuals actively shape their own lives and environments within the potentials and limits given by social, cultural, and biological constraints. These conceptualizations argue that healthy aging is best described as a dynamic interaction between individuals and their environment. In line with these prominent lifespan theories, the most recent model of healthy aging by the World Health Organization (WHO) does not define a specific threshold of functioning or health as a key to healthy aging. Instead, the WHO approach argues that healthy aging is an ongoing process between individuals' abilities, including intrinsic capacities (i.e. composite of all physical and mental capacities of an individual) and environmental factors (World Health Organization, 2015).

When assessing healthy aging in psychological research, one well-studied outcome is subjective well-being (Baltes & Smith, 2003). Subjective well-being is a central concept in lifespan psychology and gerontology in particular. It is portrayed as a multidimensional construct that includes both affective and cognitive components such as evaluations of satisfaction with life or particular life domains (Diener, Suh, Lucas, & Smith, 1999). The experience of affect is the emotional component of subjective well-being. In order to understand subjective well-being, one must acknowledge its potential to fluctuate based on contextual information in everyday life. In particular, affect has received particular attention with regard to its within-person variability, which is also referred to as intraindividual variability. Fiske and Rice (1955) define intraindividual variability as the stable difference between an individuals' two responses to the same stimuli in the same situation at two different time points. Previous research has shown that affect varies considerably across situations and across different cognitive states (Brose, Schmiedek, Lövdén, & Lindenberger, 2012; Schmiedek, Lövdén, & Lindenberger, 2013). This variability and possibility to adapt one's affect to changing environments is viewed as an important indicator of the plasticity of the human psyche and should not be treated merely as measurement error (Baltes & Baltes, 1990). Therefore, the focus on repeated high-frequency measurements within an individual obtained from everyday life data should help to understand intraindividual variability in affect in more depth.

1.1 Micro-Longitudinal Sampling of Affect

Due to the technological progress in the last decades, collecting individuals' data has become much easier and more cost-efficient, which allowed new research designs to emerge. Hence, micro-longitudinal studies that sample real-world data in high-frequency offer the possibility to zoom in on dynamic developmental processes and investigate intraindividual variability such as the daily fluctuations in affect. One line of psychological research is based on a nomothetic approach of averaging findings across large samples. This has helped research to identify stable individual

differences and explore psychological phenomena on a population level. However, when examining intraindividual variability, averaging all the data might lead to confounding results on the individual level (Kievit et al., 2013). The mathematical-statistical term of ergodicity implies that an ergodic dynamical system should have the same average over time as the average across the whole system (Molenaar & Campbell, 2009). This is hardly ever the case when thinking of real-world processes such as the experience of affect. Therefore, process-oriented research is by definition non-ergodic (Hamaker, 2012). This conclusion has already been stated in Cattell's (1952) data box, which posits that there are three different layers of data analysis in psychological research: a first layer investigates a high number of individuals at one point in time only, a second layer investigates a single individual over multiple measurement occasions, and a third level investigates multiple individuals over multiple measurement occasions (Cattell, 1952). The third approach allows one to examine interindividual differences and intraindividual variability simultaneously. When focusing on intraindividual variability, one can further distinguish between univariate intraindividual variability and bivariate intraindividual variability (for a review, Ram & Gerstorf, 2009; Röcke & Brose, 2013). The univariate variability approach describes the amount of affect variability as the magnitude of fluctuations. For example, older adults show less variability in affect than younger adults (Röcke, Li, & Smith, 2009). The bivariate net variability approach includes two time-varying variables and examines the co-variation of these two variables, which is referred to as within-person coupling. A recent coordinated analysis of such a bivariate approach has summarized the within-person coupling between affect and stressors. Negative affect was found to be robustly associated with the occurrence of stressors within individuals in everyday life (Stawski et al., 2019).

1.2 From Lab to Everyday Life Research

In recent years, a number of researchers have emphasized the need for collecting high-frequency everyday life data in order to study intraindividual psychological

functioning in participants' natural context (i.e., environment) in addition to traditional laboratory studies (Brose & Ebner-Priemer, 2015; Hamaker, 2012; Hoppmann & Riediger, 2009). In particular, the study of intraindividual variability in affect strongly profits from high-frequency assessments. Affect is a construct that typically varies rapidly from occasion to occasion and that is highly context-dependent (Brose & Ebner-Priemer, 2015). These adaptations to contextual change cannot be studied in laboratories without essential limits. Notably, laboratory studies have many advantages, such as control of external factors, manipulation opportunities and comparability across participants. By definition, however, laboratory studies isolate participants from their everyday lives such as routine physical activities, social interactions and context specific motivational goals (Hamaker, 2012). Reis (2012) argues that no "single study can minimize all threats to internal validity while simultaneously maximizing generalizability. Internal validity requires careful control of context, whereas external validity requires letting context vary freely" (p. 8).

Compared to traditional laboratory studies, everyday life studies have four main advantages. First, the findings have high ecological validity, which means they have high accuracy in representing the real world (Trull & Ebner-Priemer, 2013). Second, momentary self-reports minimize the retrospective biases that are more likely in traditional self-reports (Brose & Ebner-Priemer, 2015). This is particularly relevant in aging research due to an age-related decrease in working memory (Salthouse & Babcock, 1991). Third, micro-longitudinal observations allow one to study short-term within-person processes and their dynamical characteristics in psychological functioning that are at the core of many lifespan theories (Hoppmann & Riediger, 2009). Fourth, studies in naturalistic settings facilitate the assessment of contextual information and enable researchers to link situational aspects to person-specific variations (Brose & Ebner-Priemer, 2015).

New technologies such as smartphones and the Internet-of-Things can collect real-world data regularly or even continuously. This enables researchers to study

the dynamic nature of affect within a person over extended periods of time and with high control over the timing of the responses. These approaches are therefore a powerful extension of traditional longitudinal and cross-sectional designs. Everyday life measurements can include self-reports, physiological or biological data as well as observed behaviors over a predefined period of time. They can be assessed via passive sensing or active responses and task performance (Ram & Gerstorf, 2009; Trull & Ebner-Priemer, 2013). Trull and Ebner-Priemer (2013) give a comprehensive overview of the wide range of assessment methods to study individuals in their natural environment, which is sometimes referred to as "life as it is lived" (Bolger, Davis, & Rafaeli, 2003). In this dissertation, daily diaries and experience sampling studies will be used to describe and understand intraindividual variability in affect. In this context, daily diary studies refer to end-of-day questionnaires, whereas experience sampling studies rely on moment-to-moment questionnaires. In such studies, participants are prompted to answer short questions on their smartphones in everyday life. Additionally, experience sampling studies are sometimes coupled with wearable sensors to collect objective behavioral data such as physical activity through accelerometers. To sum up, these methods offer a powerful tool to study within-person processes with high ecological validity in a naturalistic setting. They minimize the retrospective recall bias of traditional self-report studies and extend self-report by assessing sensor-derived data in real time and real life.

1.3 Affect Variability in Everyday Life (AVEL) Framework

As part of this dissertation, a conceptual framework of affect variability in everyday life (AVEL) was developed. This framework argues that intraindividual variability in affect is, in addition to stable traits, also shaped by dynamic state characteristics and interactions with the environment. In the reasoning of the Whole Trait Theory (Fleeson & Jayawickreme, 2015), trait affect can be conceptualized

as a density distribution of different states of affect. The mean of this density depicts the trait affect as examined in longitudinal research over several years or in cross-sectional research. The standard deviation around this mean is interpreted as the variability in affect. Whereas affective traits are best assessed on a macro timescale, momentary variability in affect is best captured at the micro timescale with short time intervals (Hollenstein, Lichtwarck-Aschoff, & Potworowski, 2013). It is beyond the scope of this dissertation to examine all possible factors that could be associated with variability in affect. The current research examines aspects that are likely to be related to aging processes – in line with Rowe and Kahn's model (1997) of successful aging – and that are embedded in an everyday life context. First, avoiding disease and disability will be addressed by examining healthy individuals who successfully maintain functional health in everyday life despite some normative health impairments that are associated with older age. Second, everyday life studies have typically addressed engagement with life by looking at social interactions, everyday life activities and event occurrences such as uplifts and hassles (Charles et al., 2010; Luong, Charles, & Fingerman, 2011). As a lot of research concerning this topic already exists, the present dissertation will focus on less thoroughly examined factors and only implicitly address engagement with life. Third, high cognitive and physical functioning will be examined in their co-fluctuations with affect and they will be measured in everyday life contexts rather than laboratory assessments. Even though it is well-documented that affect fluctuates, little is known about how cognitive reflection processes (e.g., future time perspective and cognitive reappraisal) and physical functioning (e.g., physical pain and physical activity) co-vary with affect in everyday life. The coupling between cognition and affect has shown mixed results in previous research and the question of appropriate measurement of cognition in everyday life has not been examined sufficiently (Brose et al., 2012; Riediger, Wrzus, Schmiedek, Wagner, & Lindenberger, 2011; Salthouse & Berish, 2005; Sliwinski, Smyth, Hofer, & Stawski, 2006). Based on previous between-person research (Pressman & Cohen, 2005) co-variation between affect and physical functioning is

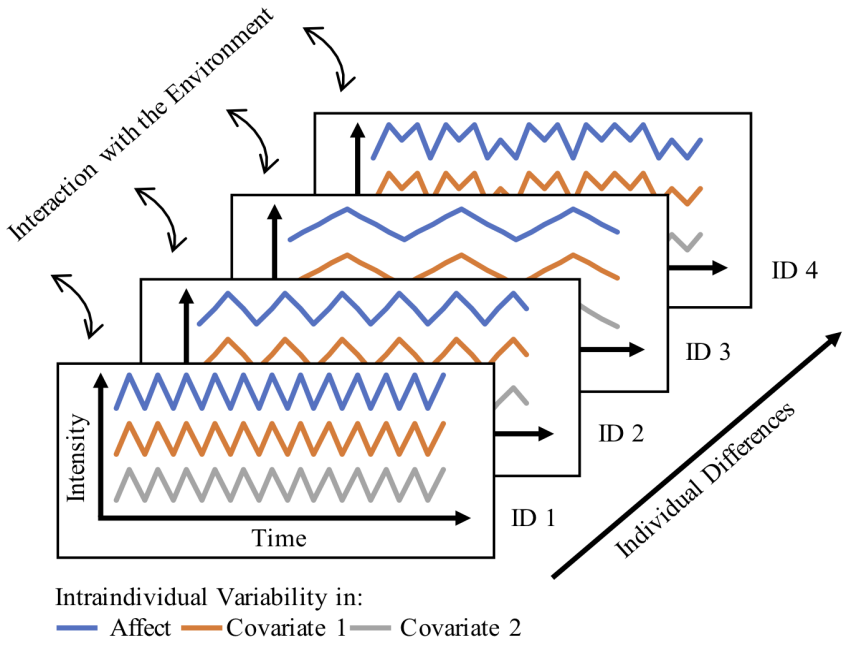

Figure 1: The AVEL framework.

expected to show stable positive correlations.

The AVEL framework describes variability in affect as embedded in an everyday life context and posits three main assumptions. First, intraindividual variability in affect and manifestation of state affect depend on individual trait differences. Second, going beyond individual differences, situational characteristics of one's everyday life are inherently associated with the ebb and flow of affect. Therefore, the within-person variability in affect is associated with co-fluctuations with other variables such as variability in cognitive reflection processes and physical functioning. Third, the interpretation of variability in affect depends on the timescale chosen to investigate the ups and downs of affect. Longer time intervals are better suited to study (in)stability of affective functioning, whereas shorter time intervals are better suited to study the adaptivity of affect to contextual changes. Figure 1 depicts the AVEL framework by illustrating multiple individuals with different levels of everyday life affect and different patterns of variability. The fluctuation in affect within an individual is in concert with variability in co-variates of affect. Both individual differences but also intraindividual variations are embedded in an individual's context (i.e., interaction with the environment).

1.4 Effect of Trait Individual Differences on Everyday Life Affect

Previous research has shown individual differences in the manifestation of daily affect in everyday life (Carstensen et al., 2011; Mroczek & Almeida, 2004). For example, older adults show less intraindividual variability in affect than younger adults, possibly due to more effective emotion regulation in older age (Röcke et al., 2009). Moreover, it is well-established that certain personality traits are associated with trait affect suggesting that a personality trait is comprised of cognitive, behavioral, and affective components (B. W. Roberts, 2009). When considering more micro-level timescales, state affect also demonstrates associations with personality trait profiles. Of the Big Five traits, neuroticism appears to be the most consistent predictor of state affect. Indeed, individuals with a higher level of neuroticism tend to report more daily negative affect, more stressful experiences, and they tend to have greater negative affective reactivity to these stressful events than individuals with lower levels of neuroticisms (Mroczek & Almeida, 2004). On the other hand, extraversion appears important for understanding daily positive affect, insofar as the trait predicts greater momentary positive affect, particularly when an individual acts in line with their extraverted tendencies (Fleeson, Malanos, & Achille, 2002). Above and beyond traditional personality traits such as the Big Five, it is important to investigate further trait characteristics to better understand individual differences in the manifestation of everyday life affect. The willingness and ability to forgive has been conceptualized as a stable individual differences characteristic referred to as forgivingness, in contrast to forgiveness as a state manifestation of forgivingness (Allemand, 2008). This trait seems to play a particularly crucial role in the aging process as older adults often report a stronger tendency to forgive than their younger adult counterparts (Steiner, Allemand, & McCullough, 2012). Forgivingness proves particularly valuable for reducing distress and for relationship maintenance (Hill, Turiano, Spiro, & Mroczek, 2015). Even though trait forgiveness has been found to

be associated with trait affect, it remains unclear whether these associations also apply to daily affect, similar to the more traditional individual differences characteristics such as personality traits.

1.5 Affect and Cognitive Reflection Processes in Everyday Life

The association between cognition and affect can be theoretically embedded in the Resource Allocation model (Ellis & Ashbrook, 1988). This model argues that only a limited amount of cognitive resources can be allocated to either a cognitive demanding task or to a high-arousing affective experience. The emotion per se or the attempt to regulate emotions require cognitive resources and therefore might result in poorer cognitive performance. So far, the association between affect and cognition has mainly been examined in laboratory studies. Observing both affect and cognition in everyday life has led to mixed results. On the one hand, reaction times of solving a memory updating task were found not to be associated with affective states (Salthouse & Berish, 2005; Sliwinski et al., 2006). On the other hand, working memory accuracy was found to be negatively related to negative affect on a daily level (Brose et al., 2012; Riediger et al., 2011). As a result of these mixed findings, it is questionable how well laboratory cognitive tasks designed to measure cognitive maximum performance are suited to measure cognitive processes in everyday life (Verhaeghen, Martin, & Sędek, 2012). Laboratory tasks typically assess maximum performance and therefore cognitive abilities. However, daily life does not usually require maximum performance to manage one's daily activities and duties; much rather, some extent of cognitive engagement is needed (Aschwanden, Luchetti, & Allemand, 2018). Examples of everyday life cognitive processes are, for instance, making plans throughout the day based on the perception of how much time is left, or processing emotions by cognitive reappraisal. This dissertation aims at moving away from traditional cognitive performance tests. Rather than applying

the same tasks that have been used in laboratory studies and incorporating them into an everyday life setting (e.g., using a standardized working memory task on the smartphone), this dissertation seeks to examine everyday life cognition in form of reflection processes. Two examples of intraindividual variability in everyday life cognitive reflection processes will be examined in association with affect. First, everyday life cognitive reflection will be measured by how individuals think about their future in terms of how much time is left and how many opportunities to engage in new activities they perceive in daily life. It will be differentiated between open-ended and limited time perception. A second way to assess cognition in everyday life is to examine how individuals regulate their emotions in terms of cognitive reappraisal within an emotionally taxing environment.

1.6 Affect and Physical Functioning in Everyday Life

Beside cognitive processes, physical functioning is assumed to play an important role for affect (Liao, Shonkoff, & Dunton, 2015). In contrast to cognitive processes, there seems to be a greater consensus about how to measure physical functioning in everyday life. Physical functioning is most often measured by means of biological assessments or with questionnaires such as the self-rated health scale (Idler & Benyamini, 1997). Smartphone based studies in combination with wearable sensors offer the possibility to portray physical functioning in a more externally valid manner. The WHO posits that it is not necessarily the inexistence of disease that is key to well-being in older age but rather the maintenance of functional ability despite diseases (World Health Organization, 2015). Each individual is characterized by his or her own genetic inheritance, health characteristics (e.g., blood pressure) and personal characteristics (e.g., education), which are summarized as the intrinsic capacity of an individual. As people age, these intrinsic capacities can be influenced by positive and negative environments (e.g., physiological risk factors, interpersonal

facilitators). The functional ability enables people to be and do what they have reason to value. Therefore, the functional ability consists of the interaction of the intrinsic capacity of the individual, the environmental as well as contextual characteristics. With chronological age, it is likely that the intrinsic capacity will decrease. However, the maintenance of functional ability can be achieved by compensating for these intrinsic losses with environmental factors. For example, an older individual that is likely to experience pain due to normative change will avoid situations in everyday life that trigger additional pain (Patel, Guralnik, Dansie, & Turk, 2013). Therefore, thanks to situation selection, this individual will be able to maintain functional ability in many occasions. In this dissertation, experience of pain and objectively measured levels of physical activity will be investigated as proxies for physical functioning in everyday life.

1.7 Measuring Affect on Different Timescales

Above and beyond theoretical questions of how affect is intertwined with cognitive reflection processes and physical functioning, methodological considerations when measuring affect must be taken into account in order to understand variability in affect. Traditionally, intraindividual trajectories of affect in lifespan psychology were mostly studied on a macro timescale. Previous research on well-being across the adult lifespan has shown that positive affect remains stable even in older adulthood and that negative affect decreases with age (Carstensen et al., 2011). In the last decade, research has also started to zoom in on these long-term developmental trajectories to examine short-term variability in affect, which required different approaches of assessing affect. In contrast to trait affect, momentary or daily affect is situation-specific and varies in shorter time intervals that can be captured by everyday life study designs. As a result, affective traits are best assessed on a macro timescale, whereas momentary affect is best captured on a micro timescale. Between trait affect and momentary affect, daily mood can be conceptualized as an intermediate (Hollenstein et al., 2013; E. L. Rosenberg, 1998). All three levels of

affect are interconnected by a feedback-looped system in which trait affect shapes both daily mood and momentary affect, which in turn also shapes both daily mood an trait affect (E. L. Rosenberg, 1998). However, the question of what would be an appropriate time interval to catch fluctuations in affect in everyday life remains to be answered. It is likely that daily diary methods that assess affect retrospectively at the end of the day capture daily mood, whereas the experience sampling approach truly captures intraindividual variability in momentary affect. Notably, there are also end-of-day diaries that specifically ask participants to rate their momentary affect; however, they mostly aim at reconstructing the general affect experienced throughout the day (Röcke, Hoppmann, & Klumb, 2011). These methodological differences in asking and assessing questions may capture different levels of affective functioning.

1.8 Research Questions

The aim of this dissertation is to better describe and understand variability in affect in everyday life. Following the AVEL framework, four main research questions arise. First, this work will investigate an example of an individual differences characteristic, namely trait forgivingness, in association with daily affect. Second, this present research will examine the within-person coupling between affect and two indicators of cognitive reflection processes in everyday life (i.e., future time perspective and emotion regulation). Third, this research will examine two examples of the within-person coupling between affect and physical functioning (i.e., physical pain and objectively measured levels of physical activity). Fourth, a methodological question will be addressed by looking at different timescales for measuring intraindividual variability in affect and its implications for adaptivity of affect.

- *Research Question 1*: How are individual trait differences associated with the manifestation of affect in everyday life?

- *Research Question 2*: How does affect co-vary with cognitive reflection pro-

cesses in everyday life?

- *Research Question 3*: How does affect co-vary with physical functioning in everyday life?

- *Research Question 4*: What are the implications of study design differences on the interpretation of results when measuring affect on different timescales?

Chapter 2

Methods

2.1 Procedure and Study Descriptions

To answer the four main research questions of this dissertation, data from six different micro-longitudinal studies were analyzed and summarized in five articles. Two components of the procedure were similar across all studies. First, participants answered an intensive baseline questionnaire that aimed at describing participants' stable trait characteristics. Second, all studies included a repeated measurement part that was assessed in everyday life.

To address the first research question, **Article 1** (N = 332) investigated how trait forgivingness is associated with daily affect. Participants ranged in age from 18 to 77 years with a mean age of 45.50. The study was conducted over 10 days with an end-of-day questionnaire that had to be filled in every evening.

To examine the second research question, three studies from two projects were used. **Article 2** investigated the within-person coupling between future time perception and affect by the means of two micro-longitudinal studies. In study 1 (N = 564), participants ranged in age from 20 to 75 years with a mean age of 48.30. This study was conducted across 10 days with an end-of-day questionnaire every day. In study 2 (N = 136), participants consisted of a healthy older adults' sample only. Participants ranged in age from 60 to 91 years with a mean age of 70.45 and reported their momentary future time perspective and affect two times a day across

10 days on their smartphones. **Article 3** ($N = 89$) investigated the within-person coupling between emotion regulation and affect. The sample consisted of geriatric nurses in four different nursing homes across Zurich. Participants ranged in age from 17 to 60 years with a mean age of 43.48 and worked with older adults on a daily basis. The geriatric nurses' emotion regulation strategies and affect were measured at the end of each day across 21 days.

To examine the third research question, two exemplary projects were used. **Article 4** ($N = 224$) investigated the within-person coupling between pain and affect. Participants were older adults ranging from 63 to 93 years with a mean age of 77.60 and reported their daily pain and affect across 21 days. **Article 5** ($N = 68$) investigated the within-person coupling between physical activity and affect. The study was conducted in collaboration with a nursing home in Zurich. Participants ranged in age from 65 to 93 years with a mean age of 78.00 and reported their daily affect over 7 days. Moreover, physical activity was measured continuously and objectively with an accelerometer.

Lastly, to address the fourth research question that is methodological in nature, all six studies were evaluated in terms of different timescales when measuring affect. Study 2 in article 2 used an experience sampling approach, which asked participants to rate their momentary affect, whereas all other studies used a retrospective end-of-day questionnaire to assess daily affect.

In addition to different applications of timescales, the six studies differed in three points. First, different conceptualizations of affect were used throughout the six studies. For example, traditional scales such as the positive and negative affect schedule (PANAS; Watson, Clark, & Tellegen, 1988), short-form questionnaires for affect in experience sampling studies (Wilhelm & Schoebi, 2007) and broader constructs such as subjective well-being (Diener et al., 1999) were assessed. Second, across the six studies, the age range differed from 17 to 93 years. Three studies used a broad age range across the adult lifespan, whereas the other three studies specifically examined healthy older adults. Third, studies differed in duration, ranging

from 7 to 21 days.

2.2 Statistical Approach

Analyzing large data acquired from smartphones and daily diary studies offers the opportunity to zoom in on everyday life and distinguish between intraindividual variability and interindividual differences. Multilevel modeling is a statistical approach that can split the analysis into multiple levels of interest. More specifically, multilevel modeling makes it possible to estimate within-person processes within each individual separately. It also estimates between-person differences therein taking into account the potentially different intercepts and slopes of each participant due to contextual and individual differences (Bolger & Laurenceau, 2013). In this dissertation, the models will distinguish between the person-level and at the observation-level because multiple observations are nested within each individual. Moreover, it is possible to investigate within-person and between-person moderators in order to differentiate the results in more detail. These models have three main advantages. First, they take into account that the error terms of repeated measurements within an individual are non-independent. Second, they can estimate within-person and between-person results at the same time. Third, they can handle missing data, which is very common in real-world data (Nezlek, 2012).

The results of multilevel models consist of fixed and random effects assuming that every individual can have a different starting point and have different distributions of slopes (Hoffman, 2007). Different models can be compared against each other by using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) as indicators of goodness of fit. Lower values indicate a better fit. With respect to effect sizes in multilevel modeling, global pseudo-R^2 statistics can be reported. This measure of effect size quantifies the variance in the outcome variable explained by all predictor variables in the multilevel model and can be computed similarly to the R^2 in multiple regressions (Peugh, 2010).

Chapter 3

Empirical Studies

3.1 Article I: Investigating the Affective Signature of Forgivingness Across the Adult Years

Patrick L. Hill[1,2], **Marko Katana**[3,4], Mathias Allemand[3,4]

[1] Department of Psychological and Brain Science, Washington University, St. Louis, USA

[2] Department of Psychology, Carleton University, Ottawa, Canada

[3] Department of Psychology, University of Zurich, Zurich, Switzerland

[4] University Research Priority Program (URPP) "Dynamics of Healthy Aging", University of Zurich, Zurich, Switzerland

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Abstract

Though dispositional forgiveness has been associated with affective well-being, it remains unclear whether these associations are consistent throughout adulthood. The current study investigated whether forgivingness interacted with chronological age or future time perspective to predict affect at the trait and daily level. Participants ($N = 332$, $M = 45.5$ years) completed baseline measures of forgivingness, positive and negative affect, and future time perspective, along with daily assessments of positive and negative affect for up to ten days. Results suggest that the associations between forgivingness and affective well-being differ somewhat based on age and future time perspective, and level of analysis.

3.1.1 Introduction

Older individuals often report a stronger tendency to forgive than their younger adult counterparts (Allemand, 2008; Mullet, Houdbine, Laumonier, & Girard, 1998; Steiner et al., 2012). This literature often focuses on forgiveness as a personality trait, referred to as "forgivingness" (R. C. Roberts, 1995) or the dispositional tendency to forgive across situations (see R. P. Brown, 2003). One rationale for these age trends is that forgivingness may serve important functions for development during adulthood. For instance, adults who prioritize environmental mastery and reducing negative affect tend to score higher on forgivingness relative to those adults who seek out new experiences (Hill & Allemand, 2010). One potential explanation is that a focus on environmental mastery affects the skills one develops, and forgivingness would prove particularly valuable for reducing distress and for relationship maintenance (Hill, Heffernan, & Allemand, 2015).

This literature is aligned with theoretical perspectives on adult development, such as socioemotional selectivity theory (SST; Carstensen, 1995; Carstensen, Isaacowitz, & Charles, 1999). This framework suggests that adults prioritize their broader aims to promote emotional well-being. For instance, older adults tend to organize their social relationships with a focus on maintaining close associates rather than building a larger social network (e.g., Carstensen, 1992, 1993). This focus reflects a desire to promote emotional well-being and reduce relationship distress, paired with a reduced interest in novel social partners and gaining new self-information through social contacts. Older adults then should develop stronger tendencies toward forgiveness insofar that this disposition will help them achieve the social goals salient to that developmental period. Support for this claim comes from the positive associations between forgivingness and age found in adult samples (Allemand, 2008; Mullet et al., 1998; Steiner et al., 2012).

A related question then is whether older adults "benefit" more from being a forgiving individual than younger adults. Research has consistently demonstrated that forgivingness is associated with lower negative affect and higher positive affect (Allemand, Hill, Ghaemmaghami, & Martin, 2012; Hill & Allemand, 2011; Toussaint & Friedman, 2008). Research though has found mixed results regarding whether these associations differ by age during adulthood. One study found that age did interact with forgivingness to predict well-being,

in the form of stronger associations between forgivingness and well-being for older than younger adults (Toussaint, Williams, Musick, & Everson, 2001); however, another study failed to replicate these interactions (Hill & Allemand, 2011). Although being a forgiving person may facilitate the social goals salient for older adults, it remains unclear whether forgivingness is differentially associated with well-being across the adult years.

At least two limitations are present with this literature though. First, both studies failed to consider the role of future time perspective, focusing only on chronological age. A central tenet of SST is that individuals change their social goals based on their perception of time remaining in life (Carstensen et al., 1999), a perception that is not perfectly associated with their actual chronological age (Allemand et al., 2012). If forgivingness better fulfills the social motives for adults with a limited time perspective (e.g., views less time or fewer opportunities remaining), then the associations between this trait and affective well-being may be stronger for adults possessing this perspective than those viewing an unlimited future.

Second, research has focused solely on cross-sectional studies when investigating the associations between forgivingness and well-being. Cross-sectional work is valuable for identifying potential correlates but is limited with respect to understanding the factors that influence daily affective dynamics. Forgiveness as a process often involves retrospection on a slight to release oneself from negative feelings about the past (e.g., Enright, Freedman, & Rique, 1998; McCullough, Worthington Jr., & Rachal, 1997). Accordingly, it remains an open question whether forgivingness, as a trait, will hold influence prospectively on one's future affect. Well-employed measures of forgivingness include items that tap whether after a transgression, one "thinks about it a lot afterward" or if one tends to "get over it quickly" (R. P. Brown, 2003), suggesting the potential for immediate and retrospective influences on affect.

The current study sought to better understand whether the affective benefits associated with forgivingness differ across adulthood, using cross-sectional and daily diary data across 10 workdays. In line with past work, we expected higher levels of forgivingness to be associated with more positive affect and less negative affect in the cross-sectional data. However, it is unclear whether the findings from cross-sectional associations will hold for the prediction of daily affect. In addition, we tested whether these cross-sectional and daily

associations between affect and dispositional forgiveness were moderated by chronological age or future time perspective. Given the mixed findings present in the existing literature (Hill & Allemand, 2011; Toussaint et al., 2001), we did not make predictions regarding chronological age as a moderator; however, based on SST (Carstensen, 1993; Carstensen et al., 1999), we expected future time perspective to moderate the associations, insofar that adults who perceived a limited future should benefit more from forgivingness.

3.1.2 Methods

3.1.2.1 Participants

Three hundred fifty-three adults participated in an online study involving an initial survey assessment, and daily follow-up assessments across 10 work days. Twenty-one individuals were excluded due to a computer error during data collection. Thus, the final sample consisted of a total of 332 adults (48.8% female). Their age ranged from 18 to 77 years (M = 45.52, SD = 13.71). Most participants reported their primary ethnicity as White (80.7%; Hispanic, 9.3%; Asian, 3.9%; African American, 4.2%; Other, 1.8%). With respect to the highest level of education attained, 30.4% of the participants were university graduates (other categories: BA or BS (high school graduate, 26.5%; college or trade school graduate, 18.4%; master's degree, 14.8%; some postgraduate education, 6.3%, PhD, 3%; some high school or less, 0.6%).

3.1.2.2 Procedure

This study is part of a larger 2-week daily diary study carried out in the United States. Participants were a convenience sample recruited in dyads (either partners or friends) through the survey-based research platform Qualtrics panel system. The project was advertised as an examination of close relationships on a daily basis, and U.S. adult members of the panel system were able to sign up through the online platform. Given the aims of the current study, we focused on the individual-level data rather than the dyadic component. First, participants completed an initial online survey regarding forgivingness, their general level of affect and future time perspective among other measures that are not relevant for testing the current predictions. Second, participants were asked to complete

online evening surveys during two consecutive weeks from Monday to Friday, resulting in 10 days of assessment. These daily questionnaires measured the level of daily affect among other daily measures that are not relevant for this study. Each participant and his or her partner received $20 for the initial survey and $75 for the completion of at least seven of the ten daily questionnaires. Regarding the daily surveys, participants provided data on average with 7.32 repeated assessments($SD = 3.33$). From 3,320 potential observations (332 participants x 10 assessments), there were 2,318 observations (69.82%) fully completed and 2,431 observations (73.22%) with at least one value to build a daily mean score for each daily scale.

3.1.2.3 Dispositional Measures

Forgivingness. Forgivingness was assessed with the Tendency to Forgive Scale (TTF; R. P. Brown, 2003). Participants were asked to rate their general tendency to forgive assessed with five items (e.g., "I tend to get over it quickly when someone hurts my feelings," "If someone wrongs me, I often think about it a lot afterward") on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). In this study, the internal consistency in form of Cronbach's α was .77.

Affect. Trait positive and negative affect were assessed with the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988). Positive and negative affect were measured with 10 items each (e.g., excited and inspired for positive affect, and jittery and distressed for negative affect). Participants were asked to rate how they felt about each of these 20 items in general on a scale ranging from 1 (*very slightly or not at all*) to 5 (*extremely*). Cronbach's α for positive and negative affect was .91.

Future Time Perspective. Participants completed six items from the Future Time Perspective Scal (FTPS; Lang & Carstensen, 2002). Example items are "Most of my life lies ahead of me" or "I experience time as limited". These items were rated on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*), with higher scores indicating a more open-ended future time perspective. Cronbach's α was .88.

3.1.2.4 Daily Measures

Daily Affect. Daily positive and negative affect were assessed with the Scale of Positive and Negative Experience (SPANE; Diener et al., 2010), which is highly correlated with though not identical to the PANAS (Diener et al., 2010; Rahm, Heise, & Schuldt, 2017). Each subscale consists of six items (e.g., happy and joyful for positive affect, and bad and afraid for negative affect). Unlike the initial survey, participants were asked to report how they felt about these positive and negative adjectives over the past 24 hours. The scales ranged from 1 (*very rarely or never*) to 5 (*very often*). The between-person reliability estimates (Cronbach's α) for daily positive affect ranged from .91 to .95 and for daily negative affect ranged from .89 to .93. In addition, we computed the reliability of within-person change estimates following Bolger and Laurenceau (2013, p. 137). These reliability estimates were .71 and .69 for daily positive affect and negative affect, respectively.

3.1.2.5 Analytical Approach

First, we examined the associations between forgivingness and general (trait-level) affect. In this cross-sectional analysis, we used a multiple linear regression model. All predictor variables (forgivingness, chronological age, FTP and gender) were grand-mean centered. We also included a dummy variable for whether participants completed the survey as a romantic partner or as a friend, to control for any influence of dyadic partner type. We started with a model without interactions, using forgivingness as a focal predictor and controlling for chronological age, FTP, and gender. Next, we added a forgivingness by chronological age interaction term to this model and in a last step we added a forgivingness by FTP interaction term to the original model.

Second, we examined the associations between forgivingness and daily affect. This daily level analysis was conducted with multilevel modeling taking into account that the error terms are nonindependent, due to nesting of observations within individuals. Moreover, this approach allows the investigation of individual differences, as the models compute intercepts and slopes for each participant individually and accounting for random variation (e.g., Bolger & Laurenceau, 2013; Raudenbush & Bryk, 2002; Singer & Willett, 2003). We analyzed the hierarchical data with the "lme4" package (Bates, Maechler, Bolker, & Walker, 2015) in R (R Core Team, 2017).

We used a stepwise approach for the multilevel analyses (e.g., Fleeson, 2007; Meyer, Shemla, Li, & Wegge, 2015). First, we examined the hierarchical structure of the data by computing intraclass correlation coefficients and investigated the within-person variation of our timevarying variables (e.g., daily positive and negative affect). Second, we modeled random-intercept and random-slope models by adding the time-varying predictor (i.e., the time variable) as random effects to our analyses. The time variable was coded as 0, 1, 2, 3, 4, and 7, 8, 9, 10, 11, corresponding to the Monday to Friday daily diary design of the study. We did not expect substantial change of daily affect across the 10 days and therefore added the duration of the study (the time variable) merely as a control variable to our models (cf. Bolger & Laurenceau, 2013). Equivalent to the cross-sectional analysis, we started with a daily model without interactions, using forgivingness as a focal predictor and then controlling for chronological age, FTP, general affect, and gender. General positive affect was a control variable in the daily positive affect models and general negative affect was a control variable in the daily negative affect models. In a next step, we added a forgivingness by chronological age interaction term to the original model and in a last step we added a forgivingness by FTP interaction term to the original model. Models with three-way interactions (forgivingness-by-moderator-by-day) were examined for the daily analyses, but as none of these three-way interactions was significant, we refrained from including them here for simplicity.

The between-person predictors (chronological age, FTP, general affect, and gender) were grand-mean centered. Although no consensus occurs with respect to the appropriate effect sizes in multilevel modeling we employed the strategy suggested by Peugh (2010) and reported global pseudo R^2 statistics. These values represent the percentage of how much of the variance was explained by the added independent variables. However, the true R^2 cannot be computed in multilevel modeling (Nezlek, 2001).

3.1.3 Results

Descriptive statistics and correlations for the main variables are reported in Table 1. Forgivingness was significantly and positively correlated with general positive affect and with an open-ended FTP, and negatively correlated with general negative affect. However, there were no significant correlations between forgivingness and either mean daily positive

or mean negative affect. Forgivingness was not significantly correlated with chronological age. Open-ended FTP was positively correlated with general and mean daily positive affect, and negatively correlated with general and mean daily negative affect as well as with chronological age. The negative correlation between an open-ended FTP and chronological age was significant but not of a magnitude to suggest they are capturing the same construct.

Table 1: *Descriptive Statistics and Correlations Among the Main Variables*

Variable	*M*	*SD*	1	2	3	4	5	6
1. Forgivingness	4.11	1.28						
2. Trait PA	3.49	0.80	.23*					
3. Trait NA	1.76	0.72	-.29*	-.22*				
4. Mean daily PA	3.72	0.70	.07	.37*	-.23*			
5. Mean daily NA	1.86	0.70	-.04	-.25*	.42*	-.58*		
6. FTP	4.73	1.32	.18*	.58*	-.25*	.29*	-.23*	
7. Age	45.52	13.71	.10	-.02	-.20*	.02	-.08	-.42*

Note. $N = 332$. PA = positive affect, NA = negative affect, FTP = future time perspective. $^*p < .01$.

3.1.3.1 Cross-Sectional Regressions Predicting General Affect

When controlling for chronological age, FTP, and gender, forgivingness was no longer significantly associated with positive affect (Models 1A and 2A, Table 2). We did not find a moderating effect of chronological age or FTP for positive affect (Models 1A and 2A, Table 2). However, the association between forgivingness and negative affect was moderated by chronological age (Model 1B, Table 2) and FTP (Model 2B, Table 2). For older adults, forgivingness was more negatively associated with negative affect compared to younger adults (Figure 1). In addition, the association between forgivingness and negative affect was modestly more negative for participants with a more limited time perspective.

3.1.3.2 Daily Association Between Forgivingness and Daily Affect

Prior to testing longitudinal associations, we computed intraclass correlation coefficients for daily positive and negative affect (ICCs) investigating how much variance was accounted by the within-person level with regard to the total variance. Results showed that 25% of the total variance of daily positive affect and 32% of the total variance of daily negative affect were within-person. Based on the goodness-of-fit indices (-2log likelihood),

Table 2: *Association Between Forgivingness and Trait Affect Model*

	Model 1: Age as a moderator				Model 2: FTP as a moderator			
	Positive affect		Negative affect		Positive affect		Negative affect	
	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	3.53***	0.14	1.85***	0.15	3.53***	0.14	1.80***	0.15
Forgivingness	0.04	0.03	-0.09**	0.03	0.04	0.03	-0.08**	0.03
FTP	0.42***	0.03	-0.20***	0.03	0.42***	0.03	-0.19***	0.03
Age	0.01***	< 0.01	-0.02***	< 0.01	0.01***	< 0.01	-0.02***	< 0.01
Gender	-0.06	0.07	-0.10	0.07	-0.06	0.07	-0.09	0.07
Romantic partnership	0.03	0.09	0.09	0.10	0.03	0.09	0.09	0.10
Forgivingness X moderator	< 0.01	< 0.01	-0.01**	< 0.01	0.01	0.02	0.06**	0.02
Adjusted R^2	0.39		0.21		0.39		0.21	
F	34.65		14.62		34.68		15.10	

Note. $N = 332$. Coefficients shown are unstandardized coefficients. *SE* represents the standard error of the unstandardized regression coefficients. FTP = future time perspective. $^*p < .05$, $^{**}p < .001$, $^{***}p < .001$.

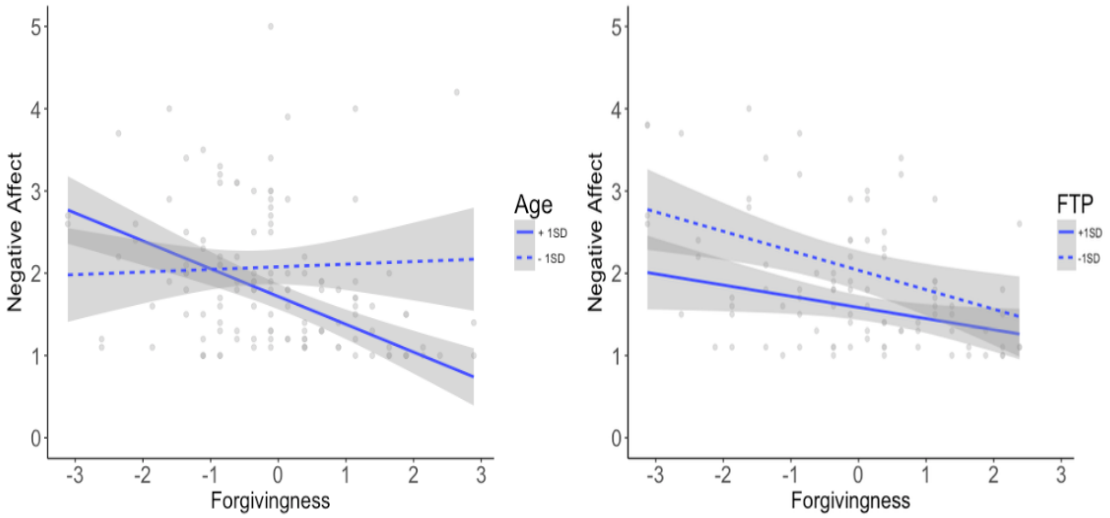

Figure 2: Interaction plots for the cross-sectional analyses.

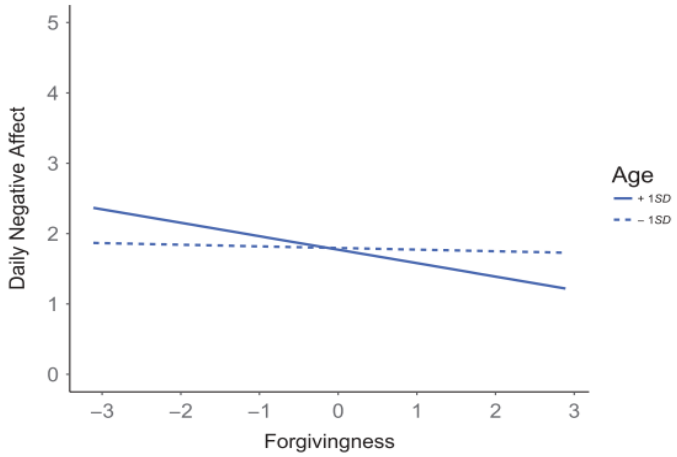

Figure 3: Interaction between forgivingness and age for predicting daily negative affect.

we found that random-intercept and random-slope models fitted better to the data than random-intercept models for daily positive ($\Delta\chi^2 = 36.27$, $p < .001$) and daily negative affect ($\Delta\chi^2 = 74.96$, $p < .001$).

Stepwise, we included the between-person variables forgivingness, chronological age, FTP, general affect, and gender into the multilevel models (see Table 3 for details). In line with the cross-sectional results, forgivingness was not significantly related to daily positive affect after controlling for chronological age, FTP, general positive affect, duration of the study, type of relationship, and gender. Forgivingness did interact with day of assessment to predict daily affect, and thus we controlled for this interaction when examining moderation by age or future time perspective. For negative affect, age significantly moderated the association between forgivingness and negative affect; no significant interactions occurred for positive affect as the outcome, or future time perspective as the moderator. As shown in Figure 2, forgivingness held a more negative association with negative affect for older than younger adults.

3.1.4 Discussion

Research on forgiveness tends to focus on individuals' progression toward becoming a more forgiving person, with less work on whether the outcomes associated with forgiveness differ across the life span. The current research provided insights into this question by examining whether the associations between forgivingness and affect differ across adulthood and provided one of the first investigations into whether forgivingness predicts daily affect prospectively. Forgivingness was associated with more affective well-being (less negative affect and more positive affect) at the bivariate, dispositional level; however, the associations with positive affect do not hold when controlling for chronological age and future time perspective, or when examining the correlations with daily-level affect. Moreover, evidence was found in crosssectional and daily data that the associations between forgivingness and negative affect depend on age, with limited evidence for future time perspective as a moderator.

Table 3: *Association Between Forgivingness and Daily Affect Model*

	Model 1: Age as a moderator				Model 2: FTP as a moderator			
	Daily positive affect		Daily negative affect		Daily positive affect		Daily negative affect	
	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Fixed Effects								
Intercept	3.67***	0.10	1.82***	0.09	3.69***	0.10	1.81***	0.09
Trait affect	0.22***	0.06	0.35***	0.06	0.22***	0.06	0.37***	0.06
Forgivingness	< 0.01	0.03	0.03	0.03	< 0.01	0.03	0.03	0.03
FTP	0.09*	0.04	-0.09**	0.03	0.09*	0.04	-0.09**	0.03
Age	< 0.01	< 0.01	-0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Gender	0.06	0.07	0.09	0.07	0.05	0.07	0.11	0.07
Romantic partnership	0.01	0.10	0.08	0.09	0.01	0.10	0.07	0.09
Time	< 0.01	< 0.01	-0.01***	< 0.01	< 0.01	< 0.01	-0.01***	< 0.01
Forgivingness X moderator	< 0.01	< 0.01	< 0.01*	< 0.01	-0.02	0.02	0.01	0.02
Forgivingness X time	-0.01**	< 0.01	0.01*	< 0.01	-0.01**	< 0.01	0.01*	< 0.01
Random Effects								
Intercept	0.37***		0.34***		0.37***		0.34***	
Time	< 0.01***		< 0.01***		< 0.01***		< 0.01***	
Residual	0.14		0.17		0.14		0.17	
AIC	3074.30		3505.30		3071.52		3504.95	
BIC	3154.76		3585.76		3151.99		3585.41	
Pseudo-R^2	0.12		0.15		0.11		0.15	

Note. Number of observations = 2316. Coefficients shown are unstandardized coefficients. *SE* represents the standard error of the unstandardized regression coefficients. General affect represents trait positive affect in the model with daily positive affect as a dependent variable and trait negative affect in the model with daily negative affect as a dependent variable. FTP = Future Time Perspective. AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion. *$p < .05$, **$p < .001$, ***$p < .001$.

3.1.4.1 Forgivingness and Well-Being

The bivariate findings replicated the well-established associations between forgivingness and dispositional positive and negative affect. However, forgivingness failed to correlate with levels of daily affect as a main effect. A recent theoretical framework (Hill, Heffernan, & Allemand, 2015) suggests that forgivingness promotes well-being through four primary pathways: reducing relationship disputes, promoting relationship maintenance, facilitating identity development, and increasing self-acceptance. When considering these potential mediators, a common theme is their focus on outcomes that typically are longer-term in nature (e.g., relationship success, identity formation, and self-acceptance). As such, forgivingness may hold more inconsistent effects on day-today well-being, depending on whether one experiences any immediate progress toward these broader outcomes. Future research should examine this claim using daily measures for forgiveness and progress toward these aims.

Regarding interaction tests, mixed support was found for the role of forgivingness on affective well-being differing by age or future time perspective. From a developmental perspective, it is valuable to note that forgivingness appears more negatively associated with negative affect for older adults, and those with a more limited time perspective. These findings provide indirect support for the notion that forgivingness may prove a more valuable "asset" for individuals with a more limited future, or of an advanced age, insofar that it better fulfills the social motives typical of that developmental period (e.g., Carstensen, 1993; Carstensen et al., 1999). In addition, it may prove valuable for adults focused on the conserver pathway versus one that focuses more on finding new experiences (Hill & Allemand, 2010). However, formal tests of these predictions require a longer longitudinal study, as well as information on the participants' stated motives for development. Indeed, it will be important for future research to consider assessing participants' social and life goals, rather than using future time perspective and chronological age as proxies for these constructs, to understand whether forgivingness is better predictive of well-being for those adults focused on relationship promotion and maintenance.

However, these findings held only in the cross-sectional data. Instead, at the daily level, we only evidenced one relatively modest interaction between forgivingness and future time perspective when predicting negative affect. Taken as a whole, the current study fails to

find universal support for arguments either for (e.g., Toussaint et al., 2001) or against (Hill & Allemand, 2011) the notion that the benefits of forgivingness differ across adulthood. Instead, developmental psychologists may wish to focus their attention on how adults' priorities for their development (e.g., focus on personal growth, environmental mastery, etc.) influence changes in forgivingness, as the trait appears to be consistently beneficial for adult well-being. Such work necessitates longer longitudinal studies though, as the current demonstration of the benefits for forgivingness is limited to largely cross-sectional data.

Additional limitations provide opportunities for future research. First, all measures were self-reported in nature and thus should be supplemented in future studies with observer-reported measures. Additional research with this sample suggests that observer-reported forgivingness was positively associated with self-reports. However no information was available beyond self-reports for the other measures in the current study. Second, participant recruitment may have been influenced by the stated desire to obtain data with dyadic partners, though it is uncertain whether the findings would differ based on this recruitment. Third, it would be valuable to consider including assessments of daily forgiveness to examine whether it holds a stronger association with daily affect.

In conclusion, developmental questions on forgiveness have taken many forms over the years, typically focusing on age trajectories in state or trait forgiveness. The current work provides initial insight into a new question, namely, suggesting that the benefits of being forgiving differ across the life span. Future research should extend this work into other developmental periods and consider the individual's motives for development. However, it appears that while forgiveness is generally valuable for an individual's well-being, the relative value may differ across adulthood.

3.1.4.2 Author Contribution

Marko Katana wrote the methods and results section of this manuscript and analyzed the data. Patrick Hill wrote the introduction and discussion section of this manuscript. Mathias Allemand provided feedback on the manuscript.

3.2 Article II: Variability in Future Time Perspective and Affect Across Adulthood and Old Age: Two Intensive Longitudinal Studies

Marko Katana[1,2], Patrick L. Hill[3,4], Mathias Allemand[1,2]

[1] Department of Psychology, University of Zurich, Zurich, Switzerland

[2] University Research Priority Program (URPP) "Dynamics of Healthy Aging", University of Zurich, Zurich, Switzerland

[3] Department of Psychological and Brain Science, Washington University, St. Louis, USA

[4] Department of Psychology, Carleton University, Ottawa, Canada

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Abstract

Objective: Despite well-documented age differences in future time perspective (FTP) and affect across the lifespan, little is known about the extent these age differences also apply to short-term variability and the within-person coupling between FTP and affect. **Method:** Study 1 used data from a daily diary study over 10 days ($N = 564$) with a wide age range across the adult lifespan (20 to 75 years; $M = 48.30$). Study 2 used data from an experience sampling study over 10 days ($N = 136$) obtained from healthy older adults (60 to 91 years; $M = 70.45$). **Results:** Data showed that 11% to 20% of the total variance in FTP was within-person and 29% to 62% of the total variance in affect was within-person. Multilevel modeling showed that occasions with a more open-ended FTP were also occasions with more positive affect and less negative affect. Older adults, as opposed to younger adults, showed a weaker within-person coupling between FTP and positive affect and negative affect. **Conclusions:** This research underpins intra- and interindividual differences in the covariation of FTP and affect in everyday life.

3.2.1 Introduction

Studying the perception of time has a rich history in lifespan developmental psychology and has been linked to chronological age (Lang & Carstensen, 2002), social motivation (Carstensen et al., 1999), self-reported health (Kooij & Van De Voorde, 2011), and healthy lifestyle choices (Tasdemir-Ozdes, Strickland-Hughes, Bluck, & Ebner, 2016). Past research has shown that limited future time perspective (FTP) is associated with more maladaptive emotional profiles (Grühn, Sharifian, & Chu, 2016) and poorer subjective well-being (Allemand & Hill, 2016; Hoppmann, Infurna, Ram, & Gerstorf, 2017). However, little is known about manifestations of FTP on a shorter timescale and affective correlates of these fluctuations. Information about short-term variability in FTP and affect would complement already existing knowledge on the macro timescale and shed more light on developmental processes of time perception in everyday life. The current research used data from two intensive longitudinal studies with different age ranges to investigate three research questions. First, do perceived time horizons fluctuate over days or moments? Second, are the fluctuations of FTP in concert with the fluctuations of affect? Third, does age moderate the within-person coupling between FTP and affect?

3.2.1.1 Variability in Future Time Perspective

Time itself plays an important role for human beings when planning the distal and proximal future (Liberman & Förster, 2008). Daily life offers many opportunities to think about the future but also about the past and the present (Shipp, Edwards, & Lambert, 2009). There are different conceptualizations of how thinking about time can be assessed such as the Zimbardo Time Perspective Inventory (ZTPI Zimbardo & Boyd, 1999), Consideration of Future Consequences Scale (CTC Strathman & Edwards, 1994) or the Future Time Perspective Scale (FTPS Lang & Carstensen, 2002). For example, initial research on temporal focus has showed in a 14-day daily diary study that the way people think about the future showed 63% within-person variability (Rush & Grouzet, 2012). In this research, we will specifically focus on the perception of the future as limited versus open-ended as this construct has shown important developmental correlates to health and well-being (Carstensen, 2006). On the one hand, FTP can be conceptualized from a lifespan devel-

opmental perspective that addresses normative developmental changes across adulthood (Carstensen, 2006; Carstensen et al., 1999). On the other hand, FTP can be conceptualized from a daily life perspective, assuming that it can show fluctuations and variability across shorter time frames. Indeed, experimental work has shown that FTP can be manipulated in the short-term by asking participants to imagine a situation that limited or expanded their FTP (Jiang, Fung, Sims, Tsai, & Zhang, 2016). When it is possible to experimentally manipulated FTP in the laboratory, it is likely that the perception of time shifts also in everyday life. Preliminary evidence for short-term variability in FTP comes from a daily diary study which examined the within-person coupling between daily FTP and gratitude in a sample of older adults (Allemand & Hill, 2019).

Despite many habitual aspects, everyday life is variable and individual goals and different social interactions throughout the day may influence the perception of time. For example, previous research has shown that cognitive processes vary considerably across situations (Schmiedek, Lövdén, & Lindenberger, 2009) and across different emotional states (Brose et al., 2012). Also short-term variability in affect was linked to diurnal rhythm and stressful encounters in everyday life (Piazza, Charles, Stawski, & Almeida, 2013; Steptoe, Leigh, & Kumari, 2011). Thus, we theorize that short-term variability in FTP should be associated with situational and social contexts in a similar vein. For instance, FTP is likely to be associated with planning for a doctor's appointment, feeling pain, or having a serious flu, making one aware of a limited future. Moreover, everyday life events such as having a full day of appointments and errands to run may shape the proximal perception of time in a more flexible way than rather distant goals in the future (Peetz, Wilson, & Strahan, 2009).

Borrowing from another field of research, intraindividual variability can be illustrated by the Whole Trait Theory (Fleeson & Jayawickreme, 2015). Research on personality has shown that traits can be conceptualized as a density distribution of states. The mean of this density depicts the trait, such as, for example, FTP as examined in longitudinal research over years or decades. The standard deviation around this mean is interpreted as the variability in the general perception of the future. This momentary interpretation of time horizons may provide a more fine-grained picture of everyday life manifestations of FTP. In a similar fashion, dynamical system theory argues that human beings constantly

exhibit regulatory dynamics by adjusting personal and situational demands to their equilibrium (see Boker, Staples, & Hu, 2016). Therefore, investigating both stable and variable components may advance the understanding of FTP in more detail.

3.2.1.2 Coupling Between Future Time Perspective and Affect

In the present research, we tested whether fluctuations of FTP are in concert with fluctuations of affect. The broaden and build theory posits that positive emotions are associated with a broadened mindset (Fredrickson, 2004) resulting in a reciprocal spiral of mutual enhancement of positive affect and a broader horizon. We argue that open-ended FTP could be one example of a broadened mindset as a manifestation of cognitive evaluations of time in everyday life. Indeed, a number of cross-sectional findings has shown that an open-ended FTP is associated with more positive and less negative affect (Allemand et al., 2012; Brothers, Gabrian, Wahl, & Diehl, 2016; Demeyer & De Raedt, 2014; Grühn et al., 2016; Hoppmann et al., 2017; Lu, Li, Fung, Rothermund, & Lang, 2018). A recent meta-analysis of 212 cross-sectional studies on the association between FTP and indicators of well-being, motivation, and behavior has reported a positive association between open-ended FTP and positive affect as well as a positive association between limited FTP and negative affect (Kooij, Kanfer, Betts, & Rudolph, 2018). Similarly, the perception of low opportunities and little trust in the future was associated with negative affect (Strunk, Lopez, & Derubeis, 2006). Yet another cross-sectional study of 2,504 participants has shown that limited FTP was associated with maladaptive emotional functioning such as lower affect, less subjective well-being, less positive emotions, and less empathy (Grühn et al., 2016).

Despite considerable insights on FTP and affect were gained from cross-sectional work, the translation of such results to the individual level is not necessarily given (Kievit et al., 2013; Molenaar, 2004). Aggregated between-person findings do not automatically account for individual differences such as different levels in FTP and affect and different strengths of associations between FTP and affect within individuals. The distinction between within-person and between-person associations is therefore crucial in order to distinguish between mean-level differences, long-term change, and short-term variability (Mroczek, Spiro, & Almeida, 2003; Ram & Gerstorf, 2009). Intensive longitudinal designs allow to disentangle

associations for each individual and therefore to compare results from individuals with themselves and with others at the same time (Bolger & Laurenceau, 2013). However, longitudinal and micro-longitudinal research on the association between FTP and affect is sparse. One available longitudinal study has found that within-person decreases in FTP over 14 years were associated with within-person decreases in well-being in a sample of 516 participants aged between 70 and 104 years (Kotter-Grühn & Smith, 2011). One micro-longitudinal study examined the within-person coupling between temporal focus and well-being. Results showed that fluctuations in temporal focus systematically co-vary with daily well-being (Rush & Grouzet, 2012). Thus, there are not only stable individual differences in the way people perceive their temporal horizons but also a potential to adapt one's way of thinking in daily life. Examinations of within-person coupling between a developmental construct like FTP and affect would add to this literature, heeding calls for understanding short-term variability in the daily life of older adults, rather than focusing solely on long-term, between-person investigations. Given that daily variability in affect and regulatory processes can hold lasting consequences on the health of older adults (Mroczek et al., 2013), it is important to understand the factors that may influence variability in daily emotion, such as changes in the individual's perception of remaining time

3.2.1.3 Age Differences in the Coupling Between Future Time Perspective and Affect

According to socioemotional selectivity theory (SST Carstensen, 2006; Carstensen et al., 1999), individuals may prefer emotionally meaningful goals over knowledge-related goals when future time is perceived as limited. Therefore, the perception of time running out should be associated with a stronger primacy on emotional goals and regulatory processes instead of acquiring knowledge. In this line of research, it has been shown that older adults generally report more limited FTP than younger adults (Lang & Carstensen, 2002). On the one hand, older adults are expected to have fewer opportunities to engage in new activities and challenges and therefore tend to choose situations more selectively, which increases their context stability (Röcke & Brose, 2013). On the other hand, older adults have greater opportunities to focus on situations in which they feel comfortable opposed to younger adults for whom situation selection is sometimes more complex due to work or

family responsibilities. For example, research has shown that older adults' everyday life is less influenced by minor life events (e.g., managing work and private life simultaneously) or emotional challenges than the lives of younger adults (Brose, Scheibe, & Schmiedek, 2013). Younger adults might be more bound to routine or deadlines in the work context, which would lead them to think more about the proximal future, whereas older adults might rather be confronted with thinking about the distal future. Therefore, older adults intentionally choose to avoid overtaxing situations when possible (Charles, 2010), such as situations that confront them with shrinking time horizons. Along similar lines, the daily experiences that are associated with a limited FTP among younger adults may be more stark or problematic in nature and thus limit the ability to find a moderate coupling between FTP and affect for older adults.

3.2.1.4 The Present Research

The present research examines variability in FTP, the coupling between FTP and affect, and age differences in this coupling by measuring fluctuations in FTP and affect in a dense manner over a short period of time. Following the theoretical reasoning described above, we formulated three hypotheses: First, we expected to find intraindividual variability in FTP. Second, we hypothesized that a more open-ended FTP should be associated with more positive and arousing affective states and less negative affect. Third, we hypothesized a weaker within-person coupling between FTP and affect in older adults than in younger adults.

To investigate these hypotheses, we used data from two intensive longitudinal studies that differed in three aspects. First, different timescales were used. In study 1, participants were asked to rate their daily FTP and affect retrospectively at the end of each day, whereas in study 2 participants were asked to rate their momentary FTP and affect three two per day on their smartphones. Second, different conceptualizations of affect were used. Research on emotion has a long history of distinguishing between valence and arousal of affect (Russell & Feldman Barrett, 1999). In this study, we aimed to include both valence and arousal as proxies of affective experience for a more complete picture of emotional well-being. Study 1 assessed daily positive and negative affect, whereas study 2 investigated the experience of arousal and calmness in addition to valence. Third, the samples differed

in age range. Study 1 targeted participants across the adult lifespan ranging from 20 to 75 years, whereas Study 2 examined specifically older adults ranged in age between 60 and 91 years. Study 1 and study 2 were designed independently from each other and served different purposes. Still, the two studies complement each other in the way that study 1 focuses on a broad age range and Study 2 expanded the age range to older age.

3.2.2 Methods Study 1

3.2.2.1 Participants

A total of 650 participants from Germany took part in the initial survey of an intensive longitudinal study across 10 days. For this analysis, we used a subsample of 564 individuals (53.8% female) who participated in both the initial survey and the daily diaries. The participants ranged in age from 20 to 75 years ($M = 48.30$, $SD = 10.02$). Out of these participants, 82.5% were married, 12.8% single and 0.7% indicated to be separated, divorced or widowed. In terms of socioeconomic status, we assessed the highest degree of education and a self-report of their income. In this sample, 54.3% of the individuals indicated to have completed the minimum amount of mandatory school years (9 years) as their highest degree of education, 17.9% indicated high-school and 27.8% indicated college/university as their highest degree of education. Most individuals (58.5%) rated their income as average, 23.4% indicated earning less than average and 18.1% indicated earning more than an average salary.

3.2.2.2 Procedure

All methods and procedures were approved by the ethics committee for psychological research at Carlton University. Participants were recruited through the survey-based research platform Qualtrics (www.qualtrics.com). Participants were also asked to invite a partner who provided self-reports and observer-report about their partners. However, in our analyses, we only used self-reports of both partners and did not include the observer-reports. After an initial survey on sociodemographic variables, participants were asked to complete an online evening survey during two consecutive weeks from Monday to Friday, resulting in 10 days of daily assessment. Every evening, participants were asked to rate

their day retrospectively including their daily future time perspective and daily affect. On average, participants completed 7.22 days (SD = 2.62) of the online survey. Participants responded to the survey on average at 7:25pm. After completion of the study, participants received $20 for the initial survey and $75 for the completion of at least seven of the ten daily questionnaires as a compensation for their study participation in addition to a general feedback about the study. All participants gave their written informed consent prior to study participation.

3.2.2.3 Measures

Daily affect. Daily affect was measured with the Scale of Positive and Negative Experience (SPANE Diener et al., 2010; Rahm et al., 2017). Participants rated how much they experienced specific affective states over the past 24 hours using valence-based adjectives on a Likert-type scale from 1 (*very rarely or never*) to 5 (*very often*). Daily positive affect was assessed with the adjectives: positive, good, pleasant, happy, joyful and contented. Daily negative affect was assessed with the adjectives: negative, bad, unpleasant, sad, afraid and angry. Within-person reliability for daily positive and negative affect were R_c = .74 and R_c = .70, respectively (see Bolger & Laurenceau, 2013, pp. 130 – 138 for details).

Daily future time perspective. Daily future time perspective was measured with a slightly modified version of the Future Time Perspective Scale (FTPS Lang & Carstensen, 2002) to make it appropriate for daily administration. Participants were asked how they thought about their future on the particular day of filling out the questionnaire. The items started with the sentence please indicate to what extent the following statements apply today. The six items were (1) "I feel that many opportunities await me in the future"; (2) "I expect that I will set many new goals in the future"; (3) "Most of my life lies ahead of me"; (4) "My future seems infinite to me"; (5) "My future is filled with possibilities"; (6) "I experience time as limited". All items were rated on a Likert-type scale ranging from 1 (*does not apply at all*) to 7 (*very much so*). Item 6 was reverse coded. The within-person reliability was R_c = .48. The exclusion of one item (i.e., "I experience time as limited") would increase the within-person reliability to R_c = .70. However, all models were run with all six items.

Control variables. We controlled for person-mean FTP (i.e., centered around the average daily FTP per individual), education, age, gender, and time. Male gender was coded as 0, female gender as 1. Time indicated the 10 days of the study. The days of the first week were coded as 0, 1, 2, 3, 4 and continued with the second week as 7, 8, 9, 10, 11 to account for the linear assessment (and potential reactivity effect) as well as the gap between Friday and Monday (Bolger & Laurenceau, 2013).

3.2.2.4 Analytical Approach

Since the primary interest of this research was to examine the within-person coupling between FTP and affect, we ran multilevel models with random intercepts and random slopes. The advantage of this statistical analysis is the ability to deal with missing data and to control for the nested structure of the data. Moreover, multilevel models allow estimations of between-person and within-person effects simultaneously (Bolger & Laurenceau, 2013; Nezlek, 2012). To account for interindividual variation we modeled the intercepts, momentary FTP, and the time variable as random effects. The between-person variables were centered around the grand-mean and the within-person variables were centered around the person-mean. We centered the time variable (i.e., how many days elapsed since the beginning of the study) at the first measurement point. Independent variables and interaction terms were added stepwise to the null model (i.e., the unconditional model) and compared against each other using AIC and BIC values as indicators of goodness of fit. Lower values indicate a better fit. With respect to effect sizes in multilevel modeling, we reported global pseudo-R^2 statistics. This measure of effect size quantifies the variance in the outcome variable explained by all predictor variables in the multilevel model and can be computed in a similar way as the R^2 in multiple regressions (Peugh, 2010). We report conditional pseudo-R^2 values representing the proportion of the total variance explained by both fixed and random effects (Nakagawa, Johnson, & Schielzeth, 2017). All the analyses were run by using the "lme4" package (Bates et al., 2015) in R (R Core Team, 2017).

3.2.3 Results Study 1

3.2.3.1 Descriptive Results

Between-person and within-person correlations among the variables of interest were computed. Daily scores were averaged per individual in order to compute between-person correlations. Average daily FTP is positively and moderately correlated with average daily positive affect (PA) and showed a negative and small association to average daily negative (NA). Participants who reported a more open-ended future time perspective tended also to report more positive and less negative daily affect. Further results showed that higher education was associated with higher average daily PA and higher average daily open FTP. Older age was associated with less average daily NA, less open FTP, and lower education. Females tended to report less daily PA and were older on average (Table 4). The within-person correlation between daily FTP and daily PA ($r(4073) = .22$, $p < .001$) was smaller (z = -6.08, $p < .001$, two-tailed) than on the between-person level ($r(564) = .46$, $p < .001$). The within-person correlation between daily FTP and daily NA ($r(4073)$ = -.10, $p < .001$) did not significantly differ ($z = 0.68$, $p = .49$, two-tailed) from the between-person correlation ($r(564)$ = -.13, $p < .01$) in terms of effect size accounting for different sample sizes.

Table 4: *Means, Standard Deviations, Between-Person and Within-Person Correlations Among the Main Variables of Study 1*

Variable	*M*	*SD*	1	2	3	4	5
1. Daily PA	3.55	0.68		-.43***	.22***		
2. Daily NA	1.84	0.67	-.45***		-.10***		
3. Daily FTP	4.05	1.27	.46***	-.13**			
4. Education	3.10	1.72	.09*	-.01	.21***		
5. Age	48.13	10.15	.03	-.19***	-.39***	-.14***	
6. Gender	0.53	0.50	-.09*	.06	-.06	.05	.10*

Note. Correlations above the diagonal depict within-person correlations (N = 4,073 observations); correlations below the diagonal depict between-person correlations (N = 564 participants); the average scores were used for the between-person correlations of the daily variables; male gender was coded as 0, female gender as 1. *$p < .05$., **$p < .01$., ***$p < .001$.

3.2.3.2 Variability in Daily FTP and Affect

The intraclass correlations (ICCs) were computed to estimate the proportion of within-person variance and between-person variance with regard to the total variance. The results showed that 89.9% of the total variance in daily FTP, 71.5% of the total variance in daily PA, 65.8% of the total variance in daily NA were found between-person. The temporal nature of the data allowed to investigate mean square successive differences (MSSD) as indices for intraindividual variability (Jahng, Wood, & Trull, 2008). Though similar to the individual standard deviation (iSD), which estimates the amplitude of the fluctuation, and the autocorrelation (AR), which estimates the temporal dependencies, MSSD combines both the amplitude of the fluctuation and the temporal dependency. A higher value refers to more variability. However, no concrete cut-off values do exist (Jahng et al., 2008; Wang & Grimm, 2012). Results illustrate that the average MSSD of daily FTP was .32, of daily positive affect .42 and of daily negative affect .47. These findings suggest that there is some amount of intraindividual variability in daily FTP but less than in daily positive and negative affect. Older individuals showed no significant association with variability in FTP ($r(564) = .09$, $p = .05$). However, older adults showed less variability in positive ($r(564) =$ -.11, $p < .001$) and negative affect ($r(564) =$ -.22, $p < .001$). This is in line with previous findings of intraindividual variability in affect (e.g., Röcke et al., 2009).

3.2.3.3 Within-Person Coupling Between Daily FTP and Affect

Multilevel modeling results showed that on days when individuals reported higher open-ended FTP, they also reported higher PA ($b = 0.23$, 95% *CI* [0.18, 0.27], $SE = 0.02$, $p < .001$) and lower NA ($b =$ -0.13, 95% *CI* [-0.18, -0.08], $SE = 0.03$, $p < .001$). When person-mean open-ended FTP was higher, individuals reported higher daily PA ($b = 0.31$, 95% *CI* [0.26, 0.34], $SE = 0.02$, $p < .001$) and lower daily NA ($b =$ -0.15, 95% *CI* [-0.18, -0.09], $SE = 0.02$, $p < .001$), suggesting that individuals with a more open-ended FTP reported more daily PA and less daily NA. Moreover, with higher age individuals reported higher daily PA ($b = 0.02$, 95% *CI* [0.01, 0.02], $SE = 0.003$, $p < .001$) and lower daily NA ($b =$ -0.02, 95% *CI* [-0.03, -0.01], $SE = 0.003$, $p < .001$). Females reported lower daily PA ($b =$ -0.14, 95% *CI* [-0.23, -0.04], $SE = 0.05$, $p < .01$) and higher daily NA ($b = 0.11$, 95% *CI* [0.01, 0.21], $SE = 0.05$, $p < .05$). The whole model for positive affect explained 78% of

the variance. A model without FTP as a predictor accounted for 74% of the total variance (Δpseudo-R^2 = .039). The model for negative affect explained 75% of the variance. A model without FTP as a predictor accounted for 69% of the total variance (Δpseudo-R^2 = .058).

3.2.3.4 Moderation Tests

In a next step, an interaction term between daily FTP and age as well as an interaction term between person-mean FTP and age were added to investigate whether the coupling between daily FTP and affect differ as a function of chronological age (Table 5). The main effects still showed that days with higher open-ended FTP were days with higher PA and lower NA. Moreover, both interaction terms were significant for PA and NA. The results for the daily FTP by age moderation effect suggest that for older adults, there was a weaker within-person coupling between daily FTP and both daily PA (b = 0.12, 95% *CI* [0.04, 0.20], *SE* = 0.04, $p < .01$) and NA (b = -0.05, 95% *CI* [-0.12, 0.03], *SE* = 0.04, $p = .200$) relative to those for younger adults (b = 0.28, 95% *CI* [0.16, 0.39], *SE* = .06, $p < .001$; b = -0.25, 95% *CI* [-0.39, -0.11], *SE* = 0.07, $p < .001$). The moderation between person-mean FTP and age was also significant. Older adults showed weaker association between FTP and both PA (b = 0.23, 95% *CI* [0.13, 0.32], *SE* = 0.05, $p < .001$) and NA (b = -0.14, 95% *CI* [-0.22, -0.05], *SE* = 0.05, $p < .01$) relative to those for younger adults (b = 0.39, 95% *CI* [0.30, 0.49], *SE* = 0.04, $p < .001$; b = -0.22, 95% *CI* [-0.32, -0.11], *SE* = 0.05, $p < .001$). Model fits for models with and without moderation were almost equivalent in terms of BIC, both for the models with daily PA (BIC with moderators = 5569.00, BIC without moderators = 5562.96) and daily NA (BIC with moderators = 6200.14, BIC without moderators = 6188.55). As the moderator age was a continuous variable, +/-1 SD was used to graph older and younger age as illustrated in Figure 3. A model without age as a predictor accounted for 0.11% less explained variance in the model for positive affect (Δpseudo-R^2 = .0011) and 0.13% for the model with negative affect (Δpseudo-R^2 = .0013).

Table 5: *Within-Person Coupling Between Daily FTP and Affect in Study 1*

	Daily positive affect				Daily negative affect			
			CI_{95}				CI_{95}	
	Estimate	*SE*	Lower	Upper	Estimate	*SE*	Lower	Upper
Fixed Effects								
Intercept	3.62***	0.04	3.55	3.69	1.86***	0.04	1.78	1.95
Daily FTP	0.23***	0.02	0.19	0.28	-0.13***	0.03	-0.18	-0.08
Person-mean daily FTP	0.31***	0.02	0.26	0.35	-0.15***	0.02	-0.19	-0.10
Education	0.01	0.01	-0.02	0.03	<0.01	0.02	-0.03	0.03
Age	0.02***	<0.01	0.01	0.02	-0.02***	<0.01	-0.03	-0.02
Gender	-0.14**	0.05	-0.23	-0.04	0.11*	0.05	0.01	0.21
Time	-0.01**	<0.01	-0.01	<0.01	-0.01***	<0.01	-0.02	-0.01
Daily FTP X age	-0.01**	<0.01	-0.01	<0.01	0.01**	<0.01	<0.01	0.01
Person-mean FTP X age	-0.01**	<0.01	-0.01	<0.01	<0.01*	<0.01	<0.01	0.01
Random Effects								
Intercept	0.52***	0.02	0.48	0.56	0.58***	0.02	0.54	0.63
Daily FTP	0.29***	0.02	0.25	0.34	0.36***	0.02	0.31	0.41
Time	0.04***	<0.01	0.03	0.04	0.04***	<0.01	0.03	0.04
Residual	0.37	0.01	0.36	0.38	0.39	0.01	0.38	0.40
Pseudo-R^2	0.78				0.75			

Note. Number of observations in model with daily positive affect: N = 4,057; number of observations in model with daily negative affect: N = 4,058; FTP = future time perspective; *SE* represents the standard error of the unstandardized regression coefficients; male gender was coded as 0, female gender as 1. Pseudo-R^2 are the conditional values representing the whole model. *p < .05, **p < .01, ***p < .001.

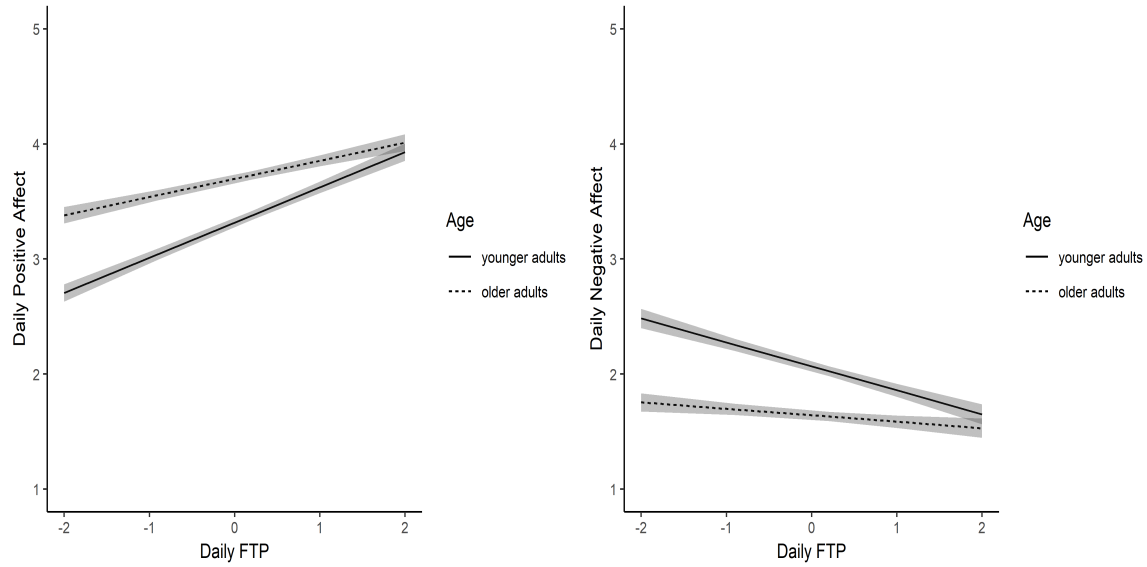

Figure 4: Age moderates the within-person associations between daily FTP and affect in Study 1. For illustration purposes, age groups (younger and older adults) were based on +/- 1 standard deviation. The 95% confidence intervals are represented in grey around the regression line.

3.2.3.5 Summary of Study 1

The current findings suggest substantial within-person variability in daily FTP, PA and NA. We found a significant positive within-person coupling between daily open-ended FTP and daily PA and a significant negative within-person coupling between daily open-ended FTP and daily NA. Moreover, we found evidence for a moderation effect of age, suggesting that the within-person coupling between FTP and affect was weaker for older adults than for younger adults.

3.2.4 Methods Study 2

3.2.4.1 Participants

Participants were drawn from an experience sampling study conducted in at the University of Zurich. A total of 136 healthy older adults (58.8% female) aged 60 to 91 years (M = 70.45, SD = 6.27) took part in this intensive longitudinal study across 10 days. A screening procedure before the study ensured that all participants obtained a value above 24 in the Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975) and a value below 18 in the General Depression Scale (Hautzinger & Bailer, 1993). Therefore, our sam-

ple of older adults was neither cognitively impaired nor clinically depressed. On average, participants reported relatively high self-reported health, as measured with a single item measure (Idler & Benyamini, 1997) using a Likert-type scale from 1 (*excellent*) to 5 (*very poor*) ($M = 1.32$, $SD = 0.34$). Of all participants, 22.8% attended secondary school (e.g., high school) as the highest form of education, 46.3% hold a university degree and 30.9% reported to have another educational background (e.g., vocational training). Out of these participants, 46.6% were married, 30.4% divorced, 7.4% single and 15.6% indicated they were widowed or separated.

3.2.4.2 Procedure

All methods and procedures were approved by the ethics committee for psychological and related research at the University of Zurich. Participants were recruited through advertisements in one national newspaper in Zurich and a university participant pool. The experience sampling study consisted of three assessments per day across 10 consecutive days on smartphones. The software movisensXS (movisens GmbH, 2016) was used to run the momentary surveys on a Motorola G. Participants were instructed on how to use the mobile device and the movisensXS application in an initial lab session. The prompts occurred randomly within three predefined time windows: 8am to 11am (morning survey), 1pm to 4pm (afternoon survey) and 6pm to 9pm (evening survey: retrospective over the day). However, the variables of interest – momentary FTP and momentary affect – were measured only in the morning and afternoon surveys and not retrospectively in the evening survey. Therefore, we focused on the morning and afternoon surveys. If participants did not answer the prompt, they were reminded up to ten times in intervals of ten minutes. Participants had the opportunity to delay or decline a prompt. There was a study help hotline for any technical inconvenience and questions related to surveys. Participants received $150 and a study feedback after study completion. Overall, there was 96.5% obtained data of the momentary items of interest (FTP and affect). All participants gave their written informed consent prior to study participation.

3.2.4.3 Measures

Momentary affect. Momentary affect was measured with a short scale developed for experience sampling studies (Wilhelm & Schoebi, 2007). The six items started with "At the moment, I feel...?" and were presented by means of six bipolar items that were used to build the following three subscales: valence ("discontent – content", "unwell – well"), energetic arousal ("tired – awake", "without energy – full of energy") and calmness ("agitated – calm", "relaxed – tense"). Each item was responded using a 0 to 6 Likert-type scale. Results showed good within-person reliabilities, momentary valence R_c = .82, momentary energetic arousal R_c =.87 and momentary calmness R_c = .84.

Momentary future time perspective. Momentary future time perspective was assessed with two bipolar items that were developed for this study. The items asked participants to first rate on a scale from "I experience my time as limited at the moment" (0) to "I experience time as infinite at the moment" (6), and then to rate on a scale from "I experience my future with limited opportunities at the moment" (0) to "I experience my future full of opportunities at the moment" (6). The two-item scale showed a within-person reliability of R_c = .77.

Control variables. In our models, we controlled for person-mean FTP, education, age, gender, and time. Male gender was coded as 0, female gender as 1. Time was coded as 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 because the study was conducted continuously throughout ten consecutive days. As the sample study 2 consisted of only older adults aged 60 years and above, we additionally controlled for general cognitive status (MMSE) and self-reported subjective health.

3.2.5 Results Study 2

3.2.5.1 Descriptive Results

The same analytic approach was used as in study 1. At the between-person level, average daily FTP was positively and moderately correlated with momentary valence, energetic arousal and calmness. Further, between-person correlative results showed that subjective health was positively associated with daily valence, energetic arousal, calmness and daily open-ended FTP. Older age was associated with more daily limited FTP, lower

scores in the MMSE and worse subjective health. Females reported less daily energetic arousal, less daily calmness and lower education (Table 6). At the within-person level, daily FTP was also positively and moderately correlated with momentary valence ($r(2720) = .35$, $p < .001$), momentary energetic arousal ($r(2720) = .26$, $p < .001$) and momentary calmness ($r(2720) = .27$, $p < .001$).

3.2.5.2 Variability in Momentary FTP and Affect

Similar to study 1, we computed the ICC scores of the main variables. The results showed that 79.6% of the total variance in momentary FTP, 46.6% of the total variance in momentary valence, 38.3% of the total variance in momentary energetic arousal and 48.6% of the total variance in momentary calmness was found between-person. As a measure of intraindividual variability (see study 1), MSSD scores were computed. Findings suggest that there is some amount of intraindividual variability in momentary FTP (1.13) but less than in momentary valence (1.63), momentary energetic arousal (2.44) and momentary calmness (1.98). Older age showed no significant association with variability in FTP ($r(136) = .15$, $p = .08$), valence ($r(136) = .11$, $p = .20$), energetic arousal ($r(136) = .10$, $p = .24$), or calmness ($r(136) = .13$, $p = .14$) in this sample.

3.2.5.3 Within-Person Coupling Between Momentary FTP and Affect

Results of the multilevel models showed that when individuals reported higher open-ended FTP, they also reported higher positive valence ($b = 0.40$, 95% *CI* [0.27, 0.52], *SE* $= 0.06$, $p < .001$), higher energetic arousal ($b = 0.42$, 95% *CI* [0.28, 0.55], *SE* $= 0.07$, $p < .001$) and higher calmness ($b = 0.33$, 95% *CI* [0.21, 0.46], *SE* $= 0.06$, $p < .001$). Similar to study 1, higher person-mean open-ended FTP was associated with higher momentary positive valence ($b = 0.13$, 95% *CI* [0.01, 0.25], *SE* $= 0.06$, $p < .05$), higher energetic arousal ($b = 0.20$, 95% *CI* [0.08, 0.33], *SE* $= 0.06$, $p < .01$) and higher calmness ($b = 0.24$, 95% *CI* [0.11, 0.37], *SE* $= 0.07$, $p < .001$). Moreover, better subjective health was associated with higher momentary positive valence ($b = 0.30$, 95% *CI* [0.05, 0.56], *SE* $= 0.14$, $p < .05$) and higher momentary energetic arousal ($b = 0.35$, 95% *CI* [0.09, 0.61], *SE* $= 0.13$, $p < .05$). No main effects of education, age and gender were found in these models. The whole model for valence explained 61% of the variance. A model without

Table 6: *Means, Standard Deviations, Between-Person and Within-Person Correlations Among Main Variable of Study 2*

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1. Momentary valence	4.93	0.91		.52***	.55***	.35***				
2. Momentary energetic arousal	4.42	0.96	.70***		.29***	.26***				
3. Momentary calmness	4.64	1.04	.76***	.72***		.27***				
4. Momentary FTP	3.64	1.47	.27**	.36***	.37***					
5. MMSE	27.79	1.15	-.02	.07	.08	.15				
6. Education	4.64	1.27	-.19	-.08	-.06	.10	.22*			
7. Subjective health	3.76	0.69	.33***	.36***	.33***	.35***	.02	-.04		
8. Age	71.45	6.27	.01	-.05	-.11	-.37***	-.24**	$< .01$	-.17*	
9. Gender	0.59	0.49	.17	-.18*	-.17*	-.07	-.03	-.31***	.02	-.07

Note. Correlations above the diagonal depict within-person correlations (N = 2,720 observations); correlations below the diagonal depict between-person correlations (N = 136 participants); the average scores were used for the between-person correlations of the momentary variables; MMSE = mini mental state examination; male gender was coded as 0, female gender as 1. *$p < .05$, **$p < .01$, ***$p < .001$.

FTP as a predictor accounted for 49% of the total variance (Δpseudo-R^2 = .123). The model for calmness explained 58% of the variance. A model without FTP as a predictor accounted for 49% of the total variance (Δpseudo-R^2 = .092). The model for energetic arousal explained 49% of the variance. A model without FTP as a predictor accounted for 42% of the total variance (Δpseudo-R^2 = .076).

3.2.5.4 Moderation Tests

As a next step, we examined whether age moderated the within-person coupling between momentary FTP and affect as well as whether age moderated the between-person association between the person-mean FTP and affect (Table 7). Age did not moderate the within-person coupling between FTP and valence, the outcome most conceptually similar to PA and NA in study 1. However, there was a significant age moderation in the coupling between momentary FTP and momentary energetic arousal (Table 7). A visualization of these results is shown in Figure 4, using lines to represent +/-1 *SD* of chronological age. In line with the results of study 1, young older adults have a stronger intraindividual coupling between momentary FTP and momentary energetic arousal (b = 0.29, 95% *CI* [0.10, 0.49], *SE* = .10, $p < .01$) than old older adults (b = 0.09, 95% *CI* [-0.20, 0.37], *SE* = 0.15, p = .57). A model without age as a predictor accounted for 0.32% less explained variance in the model for valence (Δpseudo-R^2 = .003), 0.56% less for the model with calmness (Δpseudo-R^2 = .006) and 3.12% less for the model with energetic arousal (Δpseudo-R^2 = .031).

3.2.5.5 Summary of Study 2

Findings demonstrated substantial within-person variability in momentary FTP, valence, calmness and energetic arousal. We found a significant positive within-person coupling of momentary open-ended FTP with momentary valence, calmness and energetic arousal. Moreover, we found partial support for a moderating effect of age in this sample of older adults. Only the within-person coupling between FTP and energetic arousal was moderated by age, representing a weaker association for old older adults than for young older adults.

Table 7: *Within-Person Coupling Between Momentary FTP and Affect in Study 2*

	Momentary valence				Momentary calmness				Momentary energetic arousal			
			CI_{95}				CI_{95}				CI_{95}	
	Estimate	*SE*	Lower	Upper	Estimate	*SE*	Lower	Upper	Estimate	*SE*	Lower	Upper
Fixed Effects												
Intercept	5.06***	0.14	4.77	5.33	4.74***	0.15	4.45	5.03	4.56***	0.14	4.28	4.84
Momentary FTP	0.40***	0.06	0.28	0.52	0.34***	0.06	0.21	0.46	0.43***	0.07	0.30	0.56
Person-mean daily FTP	0.14*	0.07	0.01	0.28	0.25***	0.07	0.11	0.40	0.21***	0.07	0.08	0.34
MMSE	0.06	0.08	-0.10	0.22	0.14	0.08	-0.02	0.31	0.12	0.08	-0.04	0.28
Subjective health	0.33*	0.13	0.07	0.58	0.25	0.14	-0.03	0.54	0.34*	0.14	0.07	0.62
Education	-0.14*	0.07	-0.28	<0.01	-0.12	0.08	-0.26	0.03	-0.14	0.07	-0.28	0.01
Age	0.02	0.02	-0.01	0.05	0.01	0.02	-0.02	0.04	0.02	0.02	-0.01	0.04
Gender	-0.34	0.18	-0.68	0.01	-0.19	0.20	-0.57	0.20	-0.27	0.19	-0.63	0.12
Time	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01
Momentary FTP X age	-0.02	0.01	-0.04	<0.01	-0.01	0.01	-0.04	0.01	-0.03*	0.01	-0.05	-0.01
Person-mean FTP X age	-0.01	0.01	-0.03	<0.01	-0.01	0.01	-0.03	0.01	<0.01	0.01	-0.02	0.02
Random Effects												
Intercept	0.88***	0.08	0.74	1.05	0.89***	0.09	0.73	1.08	0.78***	0.08	0.63	0.95
Momentary FTP	0.45	0.06	0.35	0.57	0.43	0.06	0.31	0.56	0.41	0.07	0.27	0.56
Time	0.01	<0.01	0.01	0.02	0.02	<0.01	0.01	0.02	0.02	<0.01	0.01	0.02
Residual	0.80	0.01	0.77	0.83	0.89	0.02	0.86	0.92	1.04	0.02	1.00	1.08
Pseudo-R^2	0.61				0.58				0.49			

Note. Number of observations in model with momentary valence: N = 1,772, with momentary calmness: N = 1,772, and with momentary energetic arousal: N = 1,773; FTP = future time perspective; MMSE = mini mental state examination; *SE* represents the standard error of the unstandardized regression coefficients; male gender was coded as 0, female gender as 1. Pseudo-R^2 are the conditional values representing the whole model. *$p < .05$, **$p < .01$, ***$p < .05$.

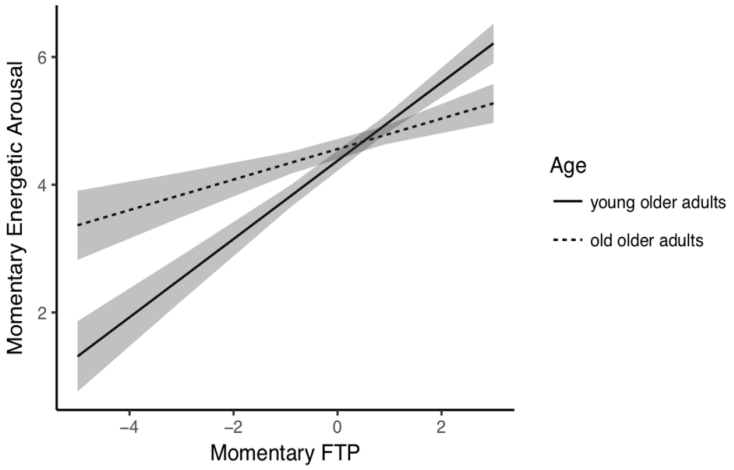

Figure 5: Age moderates the within-person associations between momentary FTP and momentary energetic arousal in study 2. For illustration purposes, age groups (young older adults and old older adults) were based on +/- 1 standard deviation. The 95% confidence intervals are represented in grey around the regression line.

3.2.6 General Discussion

This research examined three research questions. First, we investigated the intraindividual variability in FTP. Results from two intensive longitudinal studies with different age ranges showed that FTP is a construct that fluctuates within individuals from day to day and from moment to moment (11% to 20% within-person variance, respectively). The results of these studies offer new insights to the manifestation of FTP in everyday life, albeit FTP was originally conceptualized as a relatively stable construct that slowly changes as individuals move across the lifespan (Carstensen et al., 1999). Second, we examined how within-person variability in FTP was associated with affect in everyday life. Results from both studies supported the hypothesis that an open-ended FTP is associated with more positive affect, more energetic arousal, more calmness, more positive valence, and less negative affect. Third, we examined whether age was a between-person moderator for the within-person coupling between FTP and affect. The results of both studies confirmed that the within-person coupling between FTP and affect differed as a function of chronological age. Older adults, as opposed to younger and young old adults, showed weaker within-person coupling between FTP and positive affect, negative affect and energetic arousal. These differential findings were more pronounced in the adult lifespan sample that ranged from 20 to 75 years of age than in the sample of older adults with a more restrictive age range from 60 to 91 years. We discuss these primary and other findings in greater detail

below.

In discussing avenues for future research, recently researchers have suggested the need to investigate the intraindividual short-term variability in FTP (Kooij et al., 2018; Rohr, Wieck, & Kunzmann, 2017). The present research represents an important step in that direction. The results of the two intensive longitudinal studies in combination with the preliminary work by Allemand and Hill (2019) provide initial evidence for intraindividual variability in FTP across different timescales and across adulthood and old age. More specifically, in study 1, we focused on retrospective evaluations of daily FTP using a daily diary approach and found that FTP varied from day to day. In study 2, we found similar results with respect to momentary variability by using an experience sampling approach. In the latter study, we found even more within-person variability across measurements than in the daily diary study, a finding that was also reported for intraindividual variability in affect (Röcke et al., 2011). It is possible that assessment issues such as retrospective recall bias due to limits of the episodic memory (Reis, 2012) were responsible for differences in variability in FTP on different timescales (daily diary vs. experience sampling). The goal of this research was to describe the intraindividual variability in FTP. Research is now needed to explain daily and momentary variability in perceptions of time horizons.

The results of the present research confirmed the second hypothesis that a more open-ended FTP is associated with more positive and energetic affect and less negative affect in everyday life, both across and within individuals. The association between FTP and affect obtained on the between-person level was largely in line with previous cross-sectional findings (Allemand et al., 2012; Hoppmann et al., 2017) and a recent meta-analysis (Kooij et al., 2018). However, there is also a line of reasoning that argues in the opposite way, namely that limited FTP instead of open-ended FTP should be associated with higher well-being (see Carstensen, Mikels, & Mather, 2006). A discrepancy between these two approaches can partly be explained by different operational definitions of FTP in previous work (Hoppmann et al., 2017) such as the focus on distal in contrast to proximal future horizons (Liberman & Förster, 2008).

The within-person coupling between FTP and positive affect seemed stronger than the coupling between FTP and negative affect or calmness, similar to results on the between-person level (Kooij et al., 2018). These findings are in line with previous theoretical reason-

ing that individuals with a more open-ended FTP report more optimistic views about the future (De Volder & Lens, 1982). Optimistic views in terms of seeing opportunities in the future may influence the daily affective experiences and shape individuals' outlook of the future. The present results may also be viewed through the lens of the broaden-and-build model (Fredrickson, 2004) that posits that positive emotions broaden one's awareness, and encourage novel, varied, and exploratory thoughts and actions, which then produce more positive affect. Over time, this broadened behavioral and cognitive repertoire builds skills and resources. In line with this theory, perceiving the future as open-ended can be seen as a broadened mindset. In contrast, the broaden-and-build model suggests that negative emotions narrow one's perspective (Fredrickson, 2004). A temporarily limited time perspective might reflect such a narrowing process that might promote negative affect. However, the broaden-and-build theory aims at understanding in what ways positive emotions help to build resources in the longer-term and it yet to be tested what role short-term fluctuations play in this association. Another interpretation of our results is that emotion regulation strategies might reflect potential mechanisms that are responsible for an emotional upward spiral and downward spiral, respectively. For example, cognitive reappraisal is known to be associated with positive affect at the within-person level, whereas emotional suppression shows a negative association (Brans, Koval, Verduyn, Lim, & Kuppens, 2013). More concretely, it was found that open-ended FTP was associated with strategies that boost positive affect (Ramsey & Gentzler, 2014). This means that older adults' limited FTP could be associated with cognitive as well as behavioral processes that facilitate positive emotions (Strough et al., 2016). Therefore, the perception of open-ended time horizons may trigger strategies such as focusing on the moment instead of the past or future in order to up-regulate positive affect. Research is needed to investigate potential mechanisms underlying the within-person coupling between FTP and affect.

The results of the present research confirmed the third hypothesis that chronological age moderates the within-person coupling between FTP and affect. Perceiving one's daily or momentary future as open-ended or limited seemed to play a less important role for the affective experiences of older adult as compared to younger and young old adults. Similar age moderating effects were found for the within-person coupling between daily affect and event exposure such as social tension or daily stressors, where older adults were

found to show weaker coupling in everyday life than younger adults above and beyond mean-level differences (Charles & Piazza, 2009; S. B. Scott, Sliwinski, & Blanchard-Fields, 2013). Another study reported that the impact of limited FTP was smaller in older adults than in younger adults in the association between age and a specific emotion regulation strategy (e.g., coping with transgressions Allemand, 2008). Age differences in these within-person coupling might be explained, in part, with the finding that older adults prefer less overtaxing situations to avoid negative affect (Charles, 2010). Therefore, age differences in the within-person coupling between FTP and affect might be driven by situation selection as well. Previous research has found that the everyday life structure of older adults differs from the everyday life structure of younger adults due to different preference for everyday life activities and less constrains by the working environment (Jopp & Hertzog, 2010). In a similar vein, Urry and Gross (2010) argued that older adults selectively choose situations that encourage positive emotions, whereas younger adults use less situations selection but more cognitive reappraisal strategies to cope with their everyday life. Therefore, older adults might deliberately choose situations that are not associated with thinking about limited time horizons. Moreover, because chronological age is intrinsically associated with more limited time horizons, fluctuations around higher mean levels might have been less powerful for the affective experiences in older adults than in younger adults. For older adults, the perception of how much time is left during a day to pursue goals and plans might be less relevant and therefore less associated with affect than for younger adults. An alternative explanation could be that open-ended FTP is enhanced by the positivity effect that posits older adults' preference for positive over negative information in part due to age-related changes in attention and memory (see Reed, Chan, & Mikels, 2014).

3.2.6.1 Implications

The present findings may have several implications. For example, this research provides initial evidence not only that FTP fluctuates at the daily and momentary level, but also that these fluctuations matter for the person's well-being. Though theorized linkages between affect and FTP are present from the initial work on FTP (e.g., Carstensen et al., 1999), the current studies have shown that the coupling of these variables even occurs in micro-level timescales. Thus, indicating that there might be a stable and a vari-

able component of FTP has not yet been integrated in prominent theoretical models of emotional aging. Moreover, the results may inform the development of interventions to promote healthy aging processes. The next step may be to examine the directionality of FTP and affect, in order to better understand whether FTP may be an actionable target for improving the daily affective well-being of older adults. For instance, interventions may have individuals' complete daily journals wherein they write about how much time they still have left, and consider whether this influences well-being, similar to past interventions focused on gratitude journals (Emmons & McCullough, 2003). Given that future time perspective is associated with gratitude (Allemand & Hill, 2016, 2019), this literature may provide a good starting point with respect to testing whether manipulating daily FTP influences that day's affect. Another line of research has shown that focusing too much on the past or the future is associated with maladaptive affect (Hayes, 2004). More concretely, future interventions of how individuals perceive their future could help maintaining well-being in everyday life. For example, mindfulness training (Blanke & Brose, 2017) could help managing everyday life tasks at work and in private life by targeting both affective experience and living in the present.

3.2.6.2 Limitations and Future Directions

Our findings reveal a number of fruitful avenues for future research. First, we took multiple approaches to assessment intervals in the current work (daily sampling versus random morning and afternoon sampling) and found similar results. However, future research is needed to better understand the appropriate time distance between measurements of FTP. While affect is known to be highly variable from moment to moment (Eid & Diener, 1999; Röcke & Brose, 2013), less is known about which density of assessment is needed to capture variability in FTP. One recommendation from this literature is that researchers may wish to consider developing scales that are better able to capture these daily fluctuations (see Zimmermann et al., 2019). To increase the possibility of capturing fluctuation, more information on the participants in everyday life contexts would be needed such as goals that people are pursuing or daily limitations. Event-contingent sampling seems promising to capture FTP and affect in everyday life depending on the real-life context when time intervals between fluctuations are uncertain (Wrzus & Mehl, 2015). Second, this research

examined FTP as a one-dimensional construct in line with most of previous work (e.g., Grühn et al., 2016; Hill, Katana, & Allemand, 2018; Lang & Carstensen, 2002). Other researchers argued for FTP as a multidimensional construct (Kozik, Hoppmann, & Gerstorf, 2015; Rohr et al., 2017). While the adaptation of the FTPS to measure daily FTP and the two-item scale of momentary FTP provide a valuable first step in the measurement development process, future research is needed to replicate the current findings with respect to multiple components of FTP. Third, although we have no theoretical reason to believe the dyadic structure of study 1 would impact the findings, we acknowledge that there are several ways to account for the complexity of data (e.g., 3-level MLM or double intercept double slope model, Atkins, 2005; Bolger & Laurenceau, 2013). Future research focusing on dyadic research questions may apply dyadic data analyses approaches. Finally, this study primarily focused on the intraindividual variability in FTP and its association to affect. Future research is needed to investigate potential within-person moderators or mediators of the coupling between FTP and affect. One interesting pathway would be to examine whether days or moments with a more open-ended FTP are associated with days or moments with a more active lifestyle, specific emotion regulation strategies, or the perception of greater autonomy, which could in turn be associated with more positive affect.

3.2.6.3 Conclusion

The results of this research helped to advance our understanding of variability in daily and momentary future time perspective and its association with affect in adulthood and old age. This research provides three important insights for future work. First, FTP shows intraindividual variability, as it can fluctuate from day to day or moment to moment. Second, days and moments with a more open-ended FTP were days and moments with more positive affect, more energetic arousal, more calmness, more positive valence, and less negative affect. Third, older adults show weaker within-person coupling between FTP and affect than younger adults. This investigation of short-term processes in everyday life is an important complementary perspective to the lifespan development perspective on FTP.

3.2.6.4 Author Contribution

Marko Katana wrote this manuscript and analyzed the data. Patrick Hill and Mathias Allemand provided feedback on the manuscript

3.3 Article III: Emotion Regulation, Subjective Well-Being, and Perceived Stress in Daily Life of Geriatric Nurses

Marko Katana[1,2], Christina Röcke [2], Seth M. Spain [3], Mathias Allemand[1,2]

[1] Department of Psychology, University of Zurich, Zurich, Switzerland

[2] University Research Priority Program (URPP) "Dynamics of Healthy Aging", University of Zurich, Zurich, Switzerland

[3] John Molson School of Business, Concordia University, Montréal, Canada

A similar version of this manuscript has been accepted in Frontiers in Psychology

Abstract

This daily diary study examined the within-person coupling between four emotion regulation strategies and both subjective well-being and perceived stress in daily life of geriatric nurses. Participants ($N = 89$) described how they regulated their emotions in terms of cognitive reappraisal and suppression. They also indicated their subjective well-being and level of perceived stress each day over three weeks. At the within-person level, cognitive reappraisal intended to increase positive emotions was positively associated with higher subjective well-being and negatively associated with perceived stress. Suppression of the expression of positive emotions was negatively associated with subjective well-being and positively associated with perceived stress. However, cognitive reappraisal intended to down-regulate negative emotions and suppression as a strategy to inhibit the expression of negative emotions were not associated with daily well-being or perceived stress. Off-days were rated as days with higher subjective well-being and lower perceived stress in contrast to working days. At the between-person level, individuals who reported more daily negative affect reported increased suppression of positive emotions, corroborating the within-person findings. Moreover, findings indicated that nurses with more years of experience in the job reported higher subjective well-being and less perceived stress. These results provide insights into important daily emotional processes of geriatric nurses, both at workdays and in their leisure time.

3.3.1 Introduction

Emotions accompany our daily lives, particularly in contexts that provide a rich array of rewarding or stressful situations. The regulation of these emotions is often a voluntary and conscious act to ensure everyday functioning and to obey social rules. Both experimental and daily diary research have provided interesting insights into regulatory strategies and processes in the daily lives of young, middle-aged, and older adults in relation to subjective well-being (Brans et al., 2013; Brockman, Ciarrochi, Parker, & Kashdan, 2016; Cutuli, 2014; Kalokerinos, Greenaway, & Denson, 2015; Koval, Butler, Hollenstein, Lanteigne, & Kuppens, 2015; Nezlek & Kuppens, 2008; Ong & Zautra, 2015; Richardson, 2017; Scheibe, Yeung, & Doerwald, 2018; Voelkle, Ebner, Lindenberger, & Riediger, 2013). Little is known, however, about emotion regulatory processes as they are experienced in daily life contexts of particular subgroups that are facing interpersonal challenges at work and the association with subjective well-being in those contexts. Providing healthcare to older adults is an emotionally challenging profession requiring specific nurses. In light of the changing demographic landscape, elderly care will increasingly gain importance. Previous work has focused on positive and negative emotional consequences related to caregiving of older adults by informal caregivers such as family members, spouse or adult children (Fortinsky, Tennen, Frank, & Affleck, 2007; Raschick & Ingersoll-Dayton, 2004). Little is known about how professional caregivers working with older adults regulate their emotions in their daily lives (both on workdays as well as in their leisure time) and how these regulatory processes are linked with the overall daily subjective well-being and perceived stress.

3.3.1.1 Emotion Regulation in Everyday Life

Emotion regulation often involves changes in emotional responding such as increasing, decreasing, or maintaining of positive and negative emotions (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Webb, Miles, & Sheeran, 2012). These changes may occur on three levels: the kinds of emotions that individuals have, the timing of experiencing their emotions, and how they experience and express these emotions (Gross, 2015; Koole, 2009; Tamir, 2016). Emotion regulation has primarily been conceptualized as an individual difference

characteristic that tends to be relatively stable across time and situations (Gross & John, 2003) but differs across age groups (Gross et al., 1997; Hofer, Burkhard, & Allemand, 2015; Riediger & Luong, 2015; Röcke, Brose, & Kuppens, 2018; Scheibe, Sheoppes, & Staudinger, 2015; Urry & Gross, 2010). Several emotion regulation strategies have been identified (see for a review Naragon-Gainey, McMahon, & Chacko, 2017). Two common strategies are cognitive reappraisal and suppression (Gross, 1998, 2008). Reappraisal is a cognitively oriented strategy that alters the impact of an emotion by either changing the way a situation is constructed or by evaluating an emotional stimulus. Suppression is a response-focused strategy directed toward inhibiting or reducing behaviors associated with emotional responses such as facial expressions, verbal expressions, and gestures. The model of emotion regulation proposed by (Gross, 1998, 2015) is process-oriented. It suggests that reappraisal is most frequent and most efficient as an antecedent-focused strategy employed prior to or early on in an emotional episode. Following Gross, suppression is a response-focused strategy coming into play during an already ongoing emotional experience (1998, 2015). Cognitive reappraisal and suppression are strategies that aim to alter the intensity or valence of an emotional experience. This is achieved by changing one's evaluation of emotion-arousing situations or by trying not to show any external signs corresponding to an inner-felt emotion. Both strategies can be applied with regard to positive and negative emotions. In this line of reasoning, reappraisal of positive emotions means changing the way one thinks in order to increase positive emotions. Reappraisal of negative emotions means changing the way one thinks in order to decrease negative emotions. Suppression of positive emotions means inhibiting the expression of positive emotions and suppression of negative emotions means inhibiting the expression of negative emotions (Nezlek & Kuppens, 2008). Typically, an individual's goal is to enhance positive and to minimize negative emotional experience but there are some exceptions to this pattern (Riediger, Schmiedek, Wagner, & Lindenberger, 2009; Tamir, 2009). For example, the display of positive (or neutral) emotions at the workplace seems particularly important in the context of professional caregiving, as the profession of geriatric nursing requires affective and mental balance (see Mauk, 2010). Most work in applied psychology has focused on the requirement to display positive emotions in spite of the actual felt emotions that an individual may be genuinely experiencing (Grandey, 2003; B. A. Scott & Barnes, 2011).

3.3.1.2 Emotion Regulation and Subjective Well-Being

A recent meta-analysis of 79 studies has shown that emotional dynamics are associated with well-being (Houben, Van den Noortgate, Noortgate, & Kuppens, 2015). More specifically, between-person research demonstrates that cognitive reappraisal and suppression are associated with different outcomes (Gross, 2015; Gross & John, 2003; John & Gross, 2004). For example, frequent use of reappraisal has been found to be related with beneficial outcomes such as greater psychological and physical well-being and improved interpersonal functioning (Butler & Randall, 2013; Zapf, 2002). After all, individuals who habitually use reappraisal experience higher subjective well-being because the key function of reappraisal is to diminish negative emotions (Hu et al., 2014). In contrast, frequent use of expressive suppression has been found to be related to more depressive symptoms, diminished well-being and lower interpersonal functioning (Ehring, Tuschen-Caffier, Schnülle, Fischer, & Gross, 2010). Research suggests that only reappraisal leads to an enhanced control of emotion (Gross & John, 2003). Individual differences in emotion regulation have also been found to be associated with the temporal dynamics of affect. For example, the affective home base (i.e., intraindividual mean level), variability of affect and attractor strength back to home base have been suggested to be dynamic indicators of emotional experience (Kuppens, Oravecz, & Tuerlinckx, 2010). In that line of research, a recent study found that suppression was associated with higher emotional inertia (i.e., less variability due to resistance to change) of negative behavior (Koval et al., 2015; Koval, Sütterlin, & Kuppens, 2016).

Apart from differential findings when comparing regulatory strategies, both positive and negative affect also reflect different functions (Cacioppo & Gardner, 1999; Kim & Hamann, 2007; Panksepp, 1998). The seminal model of subjective well-being (Diener et al., 1999) discriminates between an affective component (positive affect and negative affect) and a cognitive component (life satisfaction and domain satisfaction). This distinction could be particularly important in contexts with highly salient display rules pitted against subjective theories about normative emotional experiences. There may be contexts in which the display of either positive or negative emotions is needed. In these cases, discrepancies between these (perceived) expectations and how one actually feels may be particularly unpleasant and dysfunctional. This is the rationale for investigating the va-

lence of emotion regulation strategies at the within-person level. Research has shown that reappraising positive emotions is related to increases in positive affect, self-esteem, and psychological adjustment. Reappraising negative emotions appears to be unrelated to these outcomes (Nezlek & Kuppens, 2008). Another daily diary study consisting of 187 students indicated that days with higher use of cognitive reappraisal were related to days with higher positive affect, and that daily suppression was related to higher negative affect (Brockman et al., 2016). In a similar vein, another experience sampling study has reported within-person results indicating that suppression was associated with higher negative affect and lower positive affect, whereas reappraisal was associated with higher positive affect (Brans et al., 2013). Such differential findings support the distinctive implications of regulating positive emotions versus negative emotions. Our hypotheses follow both theoretical notions of the functions of emotion regulation proposed by Gross (1998, 2015) and previous empirical (e.g., Nezlek & Kuppens, 2008). On the one hand, we expect daily cognitive reappraisal to be positively related to subjective well-being within individuals. On the other hand, we expect daily suppression to be negatively related to subjective well-being within individuals.

- *Hypothesis 1*: On an average day, more reappraisal is associated with higher subjective well-being.
- *Hypothesis 2*: On an average day, more suppression is associated with lower subjective well-being.

3.3.1.3 Emotion Regulation and Perceived Stress

Everyday life stressors as proxies for context have been extensively studied with regard to subjective well-being (S. B. Scott et al., 2013; Wrzus, Luong, Wagner, & Riediger, 2015). For example, an experience sampling study with on average of 55 prompts over three weeks assessed negative affect, occurrence of stressors, time passed since the stressor occurred and current preoccupation with the occurrence of this stressor (Wrzus et al., 2015). Results showed that generally more recent stressors were associated with lower activating but higher deactivating negative affect. Other studies showed that short-term variability in affect was associated with diurnal rhythm and stressful encounters in everyday life (Piazza

et al., 2013; Steptoe et al., 2011). Given the association between subjective well-being and stressors as well as the association between subjective well-being and emotion regulation, perceived stress is an important variable when describing emotional functioning in everyday life. Especially the understudied sample of geriatric nurses reflects an everyday context that requires both a rich opportunity structure and the need for adaptive emotion regulation processes (Duffy, Oyebode, & Allen, 2009; Leiter & Maslach, 2009). Geriatric nurses in their daily work contexts address various physical, psycho-social, cultural and family concerns while promoting health and emphasizing successful aging at the same time (Mauk, 2010). Despite many satisfying and rewarding aspects, the job of professional caregiving can be frustrating and stressful. For example, geriatric nurses often face chronic lack of time, irregular working hours, limited career opportunities, demanding and disruptive behaviors of the persons being cared for, or tensions between caregivers and family members of the patients. Stress and conflicts caused by the demands of caregiving may lead to negative emotions such as anger, anxiety, or depression (Pinquart & Sörensen, 2003; Richardson, 2017; Smith, Williamson, Miller, & Schulz, 2011). Therefore, individual factors such as coping skills or the ability to manage daily stress and conflicts are essential individual resources to be considered in the context of caregiving. Previous research on work-life conflict showed that conflicts at work are not independent from subjective well-being experienced during leisure time, suggesting that well-being in the workplace and well-being in leisure time should not necessarily be separated (Knecht, Wiese, & Freund, 2016).

- *Hypothesis 3*: On an average day, more reappraisal is associated with lower perceived stress.
- *Hypothesis 4*: On an average day, more suppression is associated with higher perceived stress.

3.3.1.4 The Present Study

This daily diary study focused on how the use of different emotion regulation strategies varies within-person and how these strategies are related to daily subjective well-being and perceived stress. A sample of adults who have an emotionally challenging profession,

namely geriatric nursing, have participated in the study over three consecutive weeks. Note that we do not investigate emotion regulation exclusively on workdays but on both workdays and days off work. Therefore, the results can be differentiated between the person's workday versus off-day average emotion regulation effects on subjective well-being and perceived stress. We also assume that with longer experience in the profession as a nurse, individuals develop emotion regulation strategies for dealing with challenges at work and in their leisure time (Spence Laschinger, Wilk, Cho, & Greco, 2009). To some individuals, nightshifts and the amount of work (full time vs. part time) pose an additional source of stress and decrease subjective well-being (Coffey, Skipper, & Jung, 1988; Dehring, Von Treuer, & Redley, 2018). Therefore, we controlled for non-work days, job experience, number of nightshifts and employment rate in our statistical models.

3.3.2 Methods

3.3.2.1 Participants and Procedure

This study was conducted in accordance with ethical principles of the Ethics Committee of the Faculty of Arts and Social Sciences of the University of Zurich and in accordance with the Helsinki declaration. Recruitment events were held in four different institutions (i.e., nursing homes) in the area surrounding the city of Zurich and potential participants were provided with detailed information about the project. Moreover, potential participants received a mailing with information about the study via institutional channels. Inclusion criteria were: (a) being a geriatric nurse or a geriatric nurse in training; (b) being employed or in training in one of the four participating institutions; (c) having German language skills. Recruited participants were proportionate to the size of the institution where the events were held. In total, 90 nurses enrolled for the study. One nurse was excluded from the analyses because he or she quit the study after baseline assessment and did not report any daily diary data. No further exclusion criteria were applied. Participants consisted of a convenience sample of geriatric nurses ($N = 89$). The geriatric nurses ranged in age between 17 to 60 years ($M = 43.48$ years, $SD = 11.25$). Seven nurses did not indicate their age. Two nurses were younger than 24 years and were in vocational training. Seventy-seven nurses were female, six were male, and six nurses did not indicate

their gender. The unequal gender distribution in this study mirrors the gender distribution in helping professions (Hooker, Brock, & Cook, 2016). With respect to marital status, 28 geriatric nurses were married, 39 were single, 16 were divorced or separated, one was widowed, and five did not indicate their marital status.

As we were interested in the within-person processes in daily life, we used a daily diary approach (Bolger & Laurenceau, 2013; Nezlek, 2011). Geriatric nurses provided data on daily emotion regulation, daily subjective well-being, and daily perceived stress using paper-and-pencil diaries at the end of each day for three weeks, providing an average of 18.2 days of data (SD = 4.0, range = 5-20). In total, we obtained 85% data out of the potential 1,780 observations (89 participants X 20 days). All participants gave their written informed consent prior to study participation. Throughout the study, the geriatric nurses received weekly postal reminders that stressed the importance of adhering to the daily assessment protocol. The nurses received written feedback with general findings at the end of the study.

3.3.2.2 Measures

Daily Emotion Regulation. Emotion regulation was measured with four items from the Emotion Regulation Questionnaire (ERQ Gross & John, 2003). As the ERQ is a measure of dispositional emotion regulation strategies, items were reworded slightly to make them appropriate for daily administration following the procedure implemented by Nezlek and Kuppens (2008). All items started with: "Thinking back about today, how would you respond to the following question?". Reappraisal was measured with the following two items: "When I wanted to feel a more positive emotion (such as happiness or amusement), I changed what I was thinking about" (positive reappraisal); "When I wanted to feel less negative emotion, I changed what I was thinking about" (negative reappraisal). Suppression was measured with the following two items: "When I was feeling positive emotions, I was careful not to express them" (positive suppression); "When I felt negative emotions (such as sadness, nervousness, or anger), I was careful not to express them" (negative suppression). Daily responses were made on a 7-point Likert-type scale ranging from 0 (*not at all characteristic of me*) to 6 (*very characteristic of me*).

Daily Subjective Well-Being. Subjective well-being was measured with both emo-

tional and cognitive characteristics (Diener et al., 1999). The emotional facet of subjective well-being was captured by assessing daily positive and negative affect. Affect items were selected to represent both higher and lower arousal affective experience and have been used in previous studies (e.g., Allemand et al., 2012). Daily positive affect was measured with the following items: satisfied, happy, confident, hopeful, active, energetic, joyful, relaxed, and alert. Daily negative affect was measured with the items: disappointed, sad, anxious, worried, sluggish, exhausted, angry, upset, and tired. Participants were asked to rate how strongly they felt each adjective on average during the day. All responses were made on a 7-point Likert-type scale ranging from 0 (*not at all*) to 6 (*extremely*). The within-person reliability of positive and negative affect was R_c =.79 and R_c = .75, respectively (see Bolger & Laurenceau, 2013).

To capture the cognitive-evaluative facet of subjective well-being, we used the three items reported in Nezlek and Kuppens (2008). All items started with: "Thinking back about today, how would you respond to the following question?": "Overall, how positively did you feel about yourself today" (view of self); "Thinking of your life in general, how well did things go today" (view of life in general); "How optimistic are you about how your life (in general) will be tomorrow" (optimistic view of the future). All responses were made on a 7-point Likert-type scale ranging from 0 (*not at all*) to 6 (*extremely*). The within-person reliability of the cognitive well-being scale was R_c = .81.

Daily Perceived Stress. Perceived stress was measured with a single-item measure that asked participants to rate the intensity of stress they felt during the day on a 7-point Likert-type scale ranging from 0 (*not at all*) to 6 (*extremely*). Previous research has demonstrated that a single item measure of perceived stress has satisfactory content, criterion and construct validity and can be used for assessing job stressors (Elo, Leppänen, & Jahkola, 2003; Gilbert & Kelloway, 2014).

Control Variables. Accounting for potential third variables in the coupling between emotion regulation and well-being as well as perceived stress, we controlled for whether the daily diary was answered on a workday or an off-day. This was a dichotomous variable, 0 indicating the geriatric nurse was working on that day, 1 indicating the day was an off-day. Moreover, the geriatric nurses indicated how often they worked during nightshift and provided information on their employment rate. Both indications of the number of

nightshifts and the employment rate were answered by the nurses with a percentage term. Jobs experience was assessed in terms of how many years a nurse was working in this particular profession. The time variable (i.e., how many days elapsed since the beginning of the study) was used to account for the linear assessment and potential reactivity effects during the study. The applied statistical models also controlled for the person-mean of each daily emotion regulation variable in order to differentiate between the effect of the aggregated mean-levels of emotion regulation and the daily fluctuations around this mean-level (see Bolger & Laurenceau, 2013).

3.3.2.3 Statistical Analyses

The statistical analyses focused on day-to-day within-person coupling between emotion regulation, subjective well-being, and perceived stress by using a multilevel model with random intercepts and random slopes. The statistical procedures followed the guidelines described by Bolger and Laurenceau (2013) for repeated observations (level 1) nested within individuals (level 2). The advantage of multilevel modeling analysis is its ability to handle missing data, accounting for the non-independence of the error terms within individuals with repeated measurements and modeling between-person as well as within-person effects simultaneously (Bolger & Laurenceau, 2013). Multilevel modeling analyses were performed in R (R Core Team, 2017) using the lme4 package (Bates et al., 2015) and lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2017). We ran the analyses in two steps. First, we specified unconditional models for all daily variables, i.e., models with no predictors at either level, to examine the proportion of within-person and between-person variance in the diary data and to ensure that our daily measures of interest had sufficient within-person variability to make within-person analyses feasible. For example, if everyone were stable over the study period, the only variation that would occur would be between-person variation, simply reflecting individual differences in emotion regulation, subjective well-being and perceived stress and no intraindividual covariation with any of the other time-varying variables could be expected. Second, to examine within-person relationships between emotion regulation and subjective well-being as well as perceived stress, we added all independent variables to our models in a stepwise procedure. To account for interindividual and intraindividual variation, we decomposed our daily variables

(e.g., PA) into a between-person and a within-person part. The between-person part is the aggregated mean of all observations within an individual. The within-person part is the raw value of each day. This decomposition was applied in order to truly examine the fluctuations from day to day and controlling for the between-person differences (i.e., mean value) at the same time. The between-person variables were centered around the grand-mean and the within-person variables were centered around the person-mean. The time variable depicting the repeated assessment across days was centered at the average day. An estimate of effect sizes can be computed in a similar way as R_c in multiple regressions and quantifies the variance in the outcome variable explained by all predictor variables in the multilevel model (Peugh, 2010). We report conditional pseudo-R_c values representing the proportion of the total variance explained by both fixed and random effects (Nakagawa et al., 2017).

To examine the within-person coupling between emotion regulation and subjective well-being as well as perceived stress, we performed multilevel modeling analyses that included all emotion regulation measures as independent variables at the diary level of analysis (level 1: within-person) and the daily subjective well-being measures and daily perceived stress as dependent variables. Following the suggestion of Bolger and Laurenceau (2013), we used person-mean centered independent variables on level 2 and deviation scores for each person from their own mean on level 1. More specifically, for each of the dependent variables, we estimated the following multilevel model (reappraisal of positive and negative emotions, i.e., PR and NR, and suppression of positive and negative emotions, i.e., PS and NS). The within-person variability is modeled with the regression equation:

Level 1:

$Y_{ij} = \beta_{0j} + \beta_{1j} dailyPR + \beta_{2j} dailyNR + \beta_{3j} dailyPS + \beta_{4j} dailyNS + \beta_{5j}$off-day $+ \beta_{6j} time +$ ε_{ij}

Level 2:

$\beta_{0j} = \gamma 00 + \gamma 01$(person-mean PR) $+ \gamma 02$(person-mean NR) $+ \gamma 03$(person-mean PS) $+$ $\gamma 04$(person-mean NS) $+ \gamma 05$(employment rate) $+ \gamma 06$(job experience) $+ \gamma 07$(nightshift) $+ u_{0j}$

$$\beta_{1j} = \gamma 10 + u_{1j}$$

$$\beta_{2j} = \gamma 20 + u_{2j}$$

$$\beta_{3j} = \gamma 30 + u_{3j}$$

$$\beta_{4j} = \gamma 40 + u_{4j}$$

$$\beta_{5j} = \gamma 50 + u_{5j}$$

$$\beta_{6j} = \gamma 60 + u_{6j}$$

These equations allow for individual variability in the regression coefficients, β_0 to β_6. Variability in the regression coefficients allows for individual differences in the intercepts (β_0) and the six slopes (β_1 – β_6). Therefore, different individuals may start at different levels and have different distributions of their slopes (Hoffman, 2007). In addition, the variability in intercepts can be explained by adding different predictors at the between-person level, such as person-mean PR, person-mean NR, person-mean PS, person-mean NS, employment rate, job experience and percentage of nightshift work.

3.3.3 Results

3.3.3.1 Descriptive Statistics

The within-person correlations among the main variables are depicted in Table 8. Moreover, the descriptive analysis showed that the geriatric nurses had on average 17.15 years of experience in their job (SD = 10.7) ranging from 1 year to 39 years. As can be expected, job experience was positively associated with age (r = .57, $p < .001$). The average percentage of employment rate in this sample was 82.6% (SD = 16.36), ranging from part-time nurses working in a 30% contract to full-time nurses. In 55% of the days of the study, the nurses were working. Eighteen percent of the geriatric nurses were working nightshifts. Perceived daily stress was not significantly correlated to adherence to the daily protocol (r = -.11, p = .31). The intraclass correlations (ICC) were calculated as the between-person variance (level 2) divided by the total variance, i.e., the sum of the between-person (level 2) and within-person variances plus residual variance (level 1). The ICC represents the relative proportion of variance that is between-person with respect to the total variance. The ICC of positive affect was .46, of negative affect .45, of cognitive well-being .32, and of

perceived stress .32. With regard to the emotion regulation strategies, the ICC of positive reappraisal was .40, of negative reappraisal .38, of positive suppression .49, and of negative suppression .44 (Table 8). Thus, more than half of the overall variance was at the daily, within-person level, suggesting that individuals varied around their usual level somewhat more than they differed from each other. Overall, the descriptive results show that the daily measures had sufficient within-person variances to make within-person analyses feasible. Moreover, it should be noted that the means of each measure were sufficiently far from either endpoint. Hence, floor and ceiling effects were no considerations.

Table 8: *Descriptive Statistics and Within-Person Correlations Among the Main Variables*

Variable	1	2	3	4	5	6	7	8
1. Positive affect[a]								
2. Negative affect[a]	-.63							
3. Cognitive well-being[b]	.64	-.56						
4. Perceived stress[a]	-.45	.56	-.43					
5. Positive reappraisal[a]	.13	-.11	.08	-.06				
6. Negative reappraisal[a]	.06	-.02	.02	.04	.57			
7. Positive suppression[a]	-.20	.17	-.18	.14	.01	-.01		
8. Negative suppression[a]	-.02	.03	-.04	.08	.18	.27	.22	
M	3.93	1.54	5.35	1.85	2.99	2.90	1.38	2.39
SD	1.00	1.08	1.02	1.71	1.53	1.56	1.50	1.88
ICC	0.46	0.45	0.34	0.32	0.40	0.38	0.49	0.44

Note. The descriptive statistics are based on $N = 89$. The within-person correlations are based on daily scores nested in individuals and not on aggregated scores. For $N = 1538$ observations, the minimum significant r at the .05 level is .05. [a] 0 – 6, [b] 1 – 7; ICC = intraclass correlation.

3.3.3.2 Emotion Regulation Strategies and Subjective Well-Being

Table 9 contains the results of the main multilevel modeling analyses. These results show the within-person coupling between emotion regulation strategies and three subjective well-being indicators, represented in hypotheses 1 and 2. Results with regard to reappraisal strategies showed that the daily reappraisal of positive emotions was negatively related to negative affect (b = -0.09, SE = 0.03, $p < .01$) and positively related to positive affect (b = 0.09, SE = 0.03, $p < .001$) and cognitive well-being (b = 0.09, SE = 0.03, $p <$ .01). There was no statistically significant within-person coupling between reappraisal of

negative emotions and any subjective well-being indicator ($p > .05$). Results with regard to suppression strategies showed that the daily suppression of positive emotions was negatively related to positive affect (b = -0.11, SE = 0.02, $p < .001$) and cognitive well-being (b = -0.12, SE = 0.02, $p < .001$) and positively related to negative affect (b = 0.10, SE = 0.02, $p < .001$). Again, there was no statistically significant within-person coupling between reappraisal of negative emotions and any subjective well-being indicator ($p > .05$).

Control variables in terms of person-mean emotion regulation strategies showed no significant associations except for a positive association between the person-mean of suppression of positive emotions and negative affect (b = 0.24, SE = 0.08, $p < .01$). Control variables in terms of work-related third variables in the association between emotion regulation strategies and subjective well-being showed that job experience was positively related to positive affect (b = 0.02, SE = 0.01, $p < .001$) and cognitive well-being (b = 0.02, SE = 0.01, $p < .001$). Off-days were positively related to positive affect (b = 0.21, SE = 0.06, $p < .001$) and cognitive well-being (b = 0.19, SE = 0.06, $p < .001$) and negatively related to negative affect (b = -0.33, SE = 0.04, $p < .001$).

The random effects showed that there were individual differences in the intercepts of all three indicators of subjective well-being; positive affect (var = 0.75, $p < .001$), negative affect (var = 0.47, $p < .001$), and cognitive well-being (var = 0.41, $p < .001$). There were also individual differences in the slopes on positive appraisal for positive affect (var = 0.03, $p < .001$), negative affect (var = 0.03, $p < .001$), and cognitive well-being (var = 0.04, $p < .001$). There were individual differences in slopes on negative reappraisal for positive affect ($var < 0.01$, $p < .001$) and cognitive well-being (var = 0.03, $p < .05$). There were individual differences in the slopes on negative suppression ($var < 0.01$, $p < .01$) for cognitive well-being. There were individual differences in slopes on off-day for positive affect (var = 0.19, $p < .001$), negative affect (var = 0.07, $p < .001$), and cognitive well-being (var = 0.10, $p < .001$).

3.3.3.3 Emotion Regulation Strategies and Perceived Stress

Results with regard to hypotheses 3 and 4 about the within-person coupling between perceived stress and emotion regulation strategies showed the following results (Table 9). Daily reappraisal of positive emotions was negatively related to perceived stress (b = -

0.09, $SE = 0.04$, $p < .05$). Daily suppression of positive emotions was positively related to perceived stress ($b = 0.08$, $SE = 0.03$, $p < .01$). However, daily reappraisal of negative emotions and daily suppression of negative emotions were not related to perceived stress ($p > .05$).

Control variables in terms of person-mean emotion regulation strategies showed no significant associations with perceived stress ($p > .05$). Control variables in terms of work-related third variables in the association between emotion regulation strategies and perceives stress showed that job experience was negatively related to perceived stress (b = -0.02, $SE = 0.01$, $p < .05$). Off-days were also negatively related to perceived stress (b = -1.28, $SE = 0.12$, $p < .001$). Amount of nightshift work was positively associated with perceived stress ($b = 0.66$, $SE = 0.26$, $p < .001$). The random effects showed that there were individual differences in the intercepts of perceived stress ($var = 1.46$, $p < .001$). There were also individual differences in the slopes on positive appraisal for perceived stress ($var = 0.05$, $p < .001$) and in the slopes on negative reappraisal for perceived stress ($var = 0.04$, $p < .01$). There were individual differences in the slopes of daily negative suppression ($var = 0.01$, $p < .01$) and off-days ($var = 0.89$, $p < .01$) on perceived stress.

3.3.4 Discussion

This study has three main contributions. First, previous work applying a within-person perspective on regulatory processes has been restricted to samples of college students (Brans et al., 2013; Nezlek & Kuppens, 2008; Richardson, 2017). Underlying motivational processes may differ between such student groups and the current sample of professional caregivers. For example, in the daily lives of students, there are certain display rules in place such that consider loud outbursts of emotion during class to be most often inappropriate. Most likely, however, students do not have as strong a motivation or need to regulate their feelings as professional caregivers who regularly face more extreme emotionally-relevant events and interactions and more salient display rules. Second, these results extended previous results by looking at different indicators of subjective well-being (i.e., positive affect, negative affect, cognitive well-being) and differentiating between up-regulating and down-regulating emotions in a unique sample of employees. Especially in the profession of caregivers, everyday life emotion regulation strategies are key to maintaining well-being

Table 9: *Within-Person Coupling Between Daily Emotion Regulation, Well-Being Measures, and Perceived Stress*

	Positive affect		Negative affect		Cog well-being		Perceived stress	
	b	*SE*	*b*	*SE*	*b*	*SE*	*b*	*SE*
Fixed effects								
Intercept	3.85*	0.11	1.72*	0.10	5.30*	0.09	2.46*	0.16
Daily positive reappraisal	0.09*	0.03	-0.09*	0.03	0.09*	0.03	-0.09*	0.04
Person-mean positive reappraisal	0.23	0.13	0.04	0.15	0.18	0.12	0.28	0.17
Daily negative reappraisal	-0.01	0.02	0.03	0.02	-0.01	0.03	0.07	0.04
Person-mean negative reappraisal	-0.07	0.14	0.12	0.16	-0.07	0.12	0.01	0.18
Daily positive suppression	-0.11*	0.02	0.10*	0.02	-0.12*	0.02	0.08*	0.03
Person-mean positive suppression	-0.08	0.08	0.24*	0.08	-0.05	0.07	0.02	0.10
Daily negative suppression	0.01	0.01	< 0.01	0.02	-0.01	0.02	0.03	0.03
Mean negative suppression	-0.02	0.07	-0.01	0.07	-0.09	0.06	-0.03	0.09
Employment rate	< 0.01	0.05	0.05	0.06	< 0.01	0.05	0.08	0.07
Job experience	0.02*	0.01	-0.01	0.01	0.02*	0.01	-0.02*	0.01
Off-day	0.21*	0.06	-0.33*	0.04	0.19*	0.06	-1.28*	0.12
Nightshift	-0.02	0.20	0.13	0.22	-0.33	0.18	0.66*	0.26
Time	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	-0.01	0.01
Random effects								
Between-person								
Intercept	0.75*		0.47*		0.41*		1.46*	
Daily positive reappraisal	0.04*		0.03*		0.04*		0.05*	
Daily negative reappraisal	0.01*		< 0.01		0.03*		0.04*	
Daily positive suppression	0.02		0.01		0.01		< 0.01	
Daily negative suppression	< 0.01		< 0.01		< 0.01*		0.01*	
Off-day	0.19*		0.07*		0.10*		0.89*	
Time	< 0.01*		< 0.01*		< 0.01*		< 0.01*	
Within-person								
Residual	0.34*		0.45*		0.53*		1.15*	
Pseudo-R^2	0.67		0.63		0.51		0.62	

Note. N =1456-1477 observations. *SE* represents the standard error of the unstandardized regression coefficients. Pseudo-R^2 are the conditional values representing the whole model. *$p < .05$.

and preventing stress. Third, this research extended previous findings by showing a robust pattern of coupling between reappraisal of positive emotions and subjective well-being as well as coupling between suppression of positive emotions and subjective well-being, not only on the between-person level but also on the within-person level.

3.3.4.1 Regulation of Positive Emotions Relates to Subjective Well-Being

This study found meaningful within-person coupling between emotion regulation strategies and subjective well-being. On the within-person level, the use of cognitive reappraisal to increase or up-regulate positive emotions was associated with increased well-being. Suppression to inhibit the expression of positive emotions was associated with decreased well-being. At the between-person level, some of the within-person patterns were mimicked: nurses who suppressed the expression of positive emotions were also those with higher negative affect. However, it is unclear whether these patterns also hold for long-term consequences. It has yet to be examined whether suppression of emotions might be beneficial in the long-term for other outcomes that are indirectly associated with subjective well-being. On the one hand, for geriatric nurses hiding emotions in certain situations might add to the perceived friendliness by patients and family or could be favorable for job promotions and salary. On the other hand, hiding emotions might cause a lack of perceived authenticity by patients or family members and therefore endanger long-term well-being even more. These results have also shown that not only emotion regulation strategies but also job experience was associated with indicators of daily well-being. Since job experience correlates with age, a potential explanation could be that nurses with advanced age and job experiences have learned how to use more efficient emotion regulation strategies in their daily lives (Blanchard-Fields, 2007). These results also mirror prior findings with regard to higher psychological well-being of employees with advanced job experience (Avey, Luthans, Smith, & Palmer, 2010; Kooij et al., 2013). Moreover, off-days were associated with higher daily positive affect and higher cognitive well-being. In contrast, off-days were associated with less negative affect and less perceives stress. These results underline previous research on the impact of work on subjective well-being. For example, it has been reported that high workload has a negative impact on work detachment and that low detachment from

work has in turn a negative association with well-being (Sonnentag & Bayer, 2005).

3.3.4.2 Regulation of Positive Emotions Relates to Perceived Stress

We also found interesting results with respect to daily emotion regulation and perceived stress. More than two-thirds (68%) of the overall variance of perceived stress was at the daily within-person-level, suggesting that caregivers fluctuated around their usual level of perceived stress more than they differed from each other. These results showed meaningful within-person coupling between emotion regulation strategies and perceived stress. Days on which individuals applied more cognitive appraisal of positive emotions were also days on which individuals reported less perceived stress. Days on which individuals applied suppression of positive emotions were also days on which individuals reported more perceived stress. Not surprisingly, exposure to daily stressors can be associated with a wide range of negative outcomes including decreased well-being and increased social and health problems (Lazarus & Folkman, 1984; Richardson, 2017). However, not all individuals who are exposed to high levels of stressors develop negative outcomes. In fact, a considerable number of individuals is able to remain largely unaffected by their daily stress at work. These results have shown that off-days are related with less perceived stress. This is in line with previous research that showed that most middle-aged adults perceive a vast amount of their everyday life stress at their workplace rather than in their home life (Almeida, Wethington, & Kessler, 2002). The emotional reactions involved in stress entail emotional regulation. When caregivers encounter stressful events in their daily life, emotion regulation enables them to manage their emotions. Geriatric caregiving has received attention in the aging literature mainly with a focus on informal caregivers such as family members rather than formal caregivers such as geriatric nurses. Family members are likely to be more or at least differently emotionally invested in the care recipient ("client") compared to formal caregivers. They might therefore display different responses and face different emotion regulation experiences than professionals. The latter could be considered experts in both the primary caregiving activities (e.g., assistance with activities of daily life), but also in the related task of regulating the emotions that come with the job. In addition, most research using working samples to study emotion regulation in professional contexts has focused on a different class of jobs. Typically, customer service jobs or entertainment

sector jobs have been examined, which are characterized by different and very specific rules regarding emotion regulation and particularly emotion expression (Beal, Trougakos, Weiss, & Green, 2006; Grandey, 2003). Hence, the present study served as an initial step to understand within-person processes in particularly taxing situations such as the working environment of geriatric nurses.

3.3.4.3 Type of Emotion Regulation Strategy Matters

The overall picture suggests that the type of regulated emotion and the type of regulation strategy matters for subjective well-being and perceived stress. It seems that up-regulating positive emotions in contrast to down-regulating negative emotions is differently associated with indicators of subjective well-being and perceived stress. Similar results were previously reported in student samples (Brans et al., 2013; Brockman et al., 2016; Nezlek & Kuppens, 2008; Richardson, 2017). In line with these studies, we found that up-regulation through positive reappraisal was beneficial, whereas regulation by positive suppression was not (John & Gross, 2004). The differential pattern for regulating positive and negative emotions (Kim & Hamann, 2007) follows other work showing that positive affect is not the opposite of negative affect (Diener et al., 1999; Lucas, Diener, & Suh, 1996) and supports the importance of considering the valence of emotions in a differential manner. The experience of positive emotions is important at the workplace because it helps employees obtain favorable outcomes such as greater task activity, higher achievement, and higher quality social interactions (Lyubomirsky, King, & Diener, 2005; Staw, Sutton, & Pelled, 1994). Moreover, according to Fredrickson's (1998) broaden-and-build theory, positive emotions can broaden individual's thought-action-repertoire leading to enduring personal resources, which, in turn, may facilitate behavioral flexibility and well-being (Fredrickson, 2004). To that end, the use of emotion regulation strategies with the goal of up-regulating positive emotions is particularly important in the context of professional caregiving to older adults since it may be helpful to maintain well-being. An alternative explanation for no associations between emotion strategies of negative emotions in contrast to emotion strategies of positive emotions could be due to the fact that the sample consisted of healthy individuals. Therefore, they might show only little fluctuation in negative affect in contrast to the fluctuations of positive affect and cognitive well-being.

It may well be that in some subgroups, for example clinically ill patients, reappraisal of negative emotions and suppression of negative emotions might, in some cases, be beneficial for their subjective well-being (e.g., Henry, Rendell, Green, & Mcdonald, 2008; Roberton, Daffern, & Bucks, 2012). Future research is needed to test everyday life emotion regulation strategies in different samples including clinical samples.

3.3.4.4 Implications

The present findings have several practical implications. First, knowledge about the emotion regulation strategies that professional caregivers use to influence which emotions they have, when they have them, and how they experience and express them (Gross, 1998, 2015), may be key to a better understanding of subjective well-being in geriatric nurses, employee satisfaction, and employee engagement. Emotion regulation skills could be facilitated by specific training. In this daily diary study, we demonstrated that emotion regulation strategies were related to different indicators of subjective well-being and perceived stress. Second, a focus on daily within-person processes clearly complements between-person differences research that compares individuals with higher versus lower scores in the constructs of interest (Mroczek et al., 2003). Both approaches are important. The between-person sources of variance reflect human individuality. Information about individuality may inform individually designed tools or interventions to help caregivers deal adaptively with their emotions. However, as demonstrated in this study, individuals also vary substantially within themselves from day to day. This within-person variation may give important information about the malleability and variability of states and processes of individuals' lives.

3.3.4.5 Limitations and Conclusion

Several limitations should be noted. First, we only focused on two commonly used classes of emotion regulation strategies (Gross, 1998). Future research might include more diverse strategies such as problem solving, disengagement, distraction, rumination, or relaxation (Naragon-Gainey et al., 2017; Parkinson & Totterdell, 1999; Trougakos, Beal, & Weiss, 2008). Findings from an experience sampling study have shown that distraction is one of the most used emotion regulation strategy in everyday life, and that different types

of emotion regulation strategies are used simultaneously (Brans et al., 2013). Second, we relied upon end-of-day reports regarding daily emotion regulation, subjective well-being, and perceived stress. As such, these reports were somewhat retrospective and may have been biased. For example, it is possible that such reports reflect the strongest feelings individuals had during a day, how they were feeling at the end of the day or how they were feeling when they provided the ratings (e.g., Röcke et al., 2011). Future research might include random multiple momentary assessments throughout the day (Wrzus & Mehl, 2015) to draw a more concrete picture of emotion regulation dynamics that are highly context dependent (Aldao, 2013; Kuppens, 2015; Röcke et al., 2018). This would allow to apply a more personalized approach when studying individual emotion regulation processes (Doré, Silvers, & Ochsner, 2016). Third, we used paper-and-pencil diaries, which do not offer objective time stamp information on when the diary was actually filled in. However, there is reason to believe that participants agreeing to participate in such a study do provide data that is very comparable to studies using electronic diaries (Green, Rafaeli, Bolger, Shrout, & Reis, 2006). Fourth, this research examined the everyday lives of geriatric nurses and did not distinguish between work days and off-days. However, we controlled for whether the nurse was on- or off-work. This gives us the person's workday versus off-day average emotion regulation effects, with whether it's an on- or off-day controlling for the persons' average level of workday versus off-day subjective well-being, or perceived stress. Finally, to reduce participants' burden, we used very short daily measures. Our findings may thus be limited by the use of single-item measures. Future research might examine other facets of these complex constructs. For example, it would be interesting to test the coupling between emotion regulation and subjective well-being using other conceptualizations of well-being such as psychological well-being with aspects like environmental mastery (Ryff, 1995). Environmental mastery refers to the ability to control and manage one's environment and one's efficacy in choosing environments that suit one's goals and needs. Research at the between-person level found that individuals who habitually use cognitive reappraisal showed more environmental mastery, whereas suppression was correlated negatively with the ability to control and manage the environment (Gross & John, 2003). However, it is unclear whether these associations also hold at the within-person level over time in the context of caregiving.

In conclusion, this study provides valuable insights into important emotional processes in the daily life of geriatric nurses. In particular, the results indicated that regulation through reappraisal with the goal of up-regulating positive emotions was beneficial, whereas regulation by suppressing the expression of positive emotions was not. In other words, the ability to effectively deal with emotions assists professional caregivers in managing occupational stress and maintaining subjective well-being both during workdays and in their leisure time.

3.3.4.6 Author Contribution

Marko Katana wrote this manuscript and analyzed the data. Christina Röcke, Seth Spain, and Mathias Allemand provided feedback on the manuscript.

3.4 Article IV: Intra- and Interindividual Differences in the Within-Person Association Between Daily Physical Pain and Affect of Healthy Older Adults

Marko Katana[1,2] Christina Röcke [2] Mathias Allemand[1,2]

[1] Department of Psychology, University of Zurich, Zurich, Switzerland

[2] University Research Priority Program (URPP) "Dynamics of Healthy Aging", University of Zurich, Zurich, Switzerland

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Abstract

The bidirectional interplay between chronic pain and negative affect is well-established in patient samples. However, less is known about the relationship between pain and affect of healthy older adults in their everyday lives and to what extent this association differs within and between individuals. A total of 224 participants ($M = 77.6$, $SD = 6.2$) reported their daily experience of pain, impairment by their pain and affect during 21 consecutive days. Multilevel modeling results showed that on days with increased pain individuals also reported less positive affect and more negative affect. Time-lagged results indicated a temporal carry-over from yesterday's pain to today's negative affect but not to today's positive affect. Moreover, on days where individuals reported to feel more strongly impaired by their pain, they showed a stronger within-person association between daily pain and affect in contrast to days with a weaker experience of daily impairment. Interindividual differences in the within-person association between daily pain and affect were found with regard to general health conditions and general satisfaction with health. This study demonstrated the importance of focusing on within-person associations between daily pain and affect beyond patient samples in order to better understand the maintenance of emotional stability despite daily hassles in older adults' everyday lives.

3.4.1 Introduction

Previous research has consistently shown that both affect and pain are associated with physical, psychological and social health outcomes(Jakobsson, Hallberg, & Westergren, 2004; Ong, 2010; Pandey & Choubey, 2010; Pressman & Cohen, 2005). Cross-sectional research suggests that individuals with chronic pain report lower levels of positive affect and higher levels of negative affect (Hanssen, Vancleef, Vlaeyen, & Peters, 2014; Ramirez-Maestre, Lopez Martinez, & Zarazaga, 2004; Simsek, Simsek, Yümin, Sertel, & Oztürk, 2010; Willman, Petzäll, Östberg, & Hall-Lord, 2013). Above and beyond mean-level differences, both affect and pain are known to show substantial short-term variability (Dobscha et al., 2015; Röcke et al., 2009). Even though some studies focused on short-term within-person association between pain and affect, most of these studies were conducted either using clinical samples or in younger adults. However, older adults are especially prone to experiencing at least some degree of pain in everyday life due to age-related health challenges (Patel et al., 2013). At the same time, they show remarkable day-to-day stability and longer term maintenance in emotional well-being compared to younger age groups (e.g., Röcke et al., 2009). Therefore, older adults form a particularly interesting group to study the association between pain and affect outside of the clinical context.

3.4.1.1 Experience of Pain in Older Age

Due to age-related impairments in physical health, older adults are especially at risk of experiencing at least low to moderate levels of pain as a substantial part of their everyday lives (Gibson & Lussier, 2012; Patel et al., 2013). It is well-known that pain interferes with the processing of other information. When pain is perceived as threatful, attention is drawn to the respective pain location. Therefore, pain can be a distractor from ongoing activities or goal pursuit by strengthening one's attention to a particular internal pain signal (van Damme, Crombez, & Lorenz, 2007). A large survey on a representative sample of older adults in the United States found that 53% of all participants over 65 years experienced pain within the last month (Patel et al., 2013). According to the biopsychosocial model, pain is the result of a subjective evaluation of a physical experience that is characterized not only by biological factors but also by psychological and sociocultural factors (Gatchel,

Peng, Peters, Fuchs, & Turk, 2007; Kwissa-Gajewska & Gruszczynska, 2018; Lumley et al., 2011). It is important to note that such subjective ratings depend on the individuals' own evaluation and that different individuals may have different baselines or thresholds of experiencing pain. Therefore, repeated measures within individuals and the resulting deviations from one's own mean represent an informative source of intraindividual dynamics in pain (Bolger & Laurenceau, 2013; Molenaar & Campbell, 2009). Past micro-longitudinal research examining the day-to-day variability of pain showed indeed that the experience of chronic pain varies both at the between-person and within-person levels (Affleck, Tennen, Urrows, & Higgins, 1991; Dobscha et al., 2015; Zautra, Smith, Affleck, & Tennen, 2001).

3.4.1.2 Affect in Older Age

Despite age-related decline in physical functioning (i.e., higher likelihood of pain symptoms), maintaining high levels of well-being is a central goal to most older adults and often described as a key outcome of healthy aging (Freund & Riediger, 2003; Martin, Jäncke, & Röcke, 2012). Affect is known to be a central part of individuals' well-being and can be classified into two separate dimensions, positive and negative affect (J. T. Larsen, 2017; Watson et al., 1988). For example, affect can be integrated in a feedback-based system that monitors the gap between the actual and the desired state. In this system, positive affect signals that everything is going as it ought to. Similarly, negative affect represents a discrepancy in this feedback-based monitoring system and signals that actions need to be taken (Carver & Scheier, 1990; R. J. Larsen, 2000).

In contrast to age-related decline in physical and cognitive functioning (Ghisletta, Bickel, & Lövdén, 2006; Salthouse, 2009; Strauss, Macdonald, Hunter, Moll, & Hultsch, 2002), affect is typically characterized by the maintenance of high levels of positive affect in older age (Carstensen et al., 2011; Labouvie-Vief, 2003; Mroczek & Kolarz, 1998; Stone, Schwartz, Broderick, & Deaton, 2010) until a decline during the few last years of life in several positive well-being facets (Baltes & Smith, 2003; Gerstorf et al., 2010; Gerstorf, Ram, Röcke, Lindenberger, & Smith, 2008). However, the aforementioned empirical findings focus on long-term change and allow little inference on short-term dynamics of affect in a real-life setting. Current directions in the field aim at understanding the role of intraindividual processes and focus therefore more strongly on temporal patterns of affective

experiences in daily life (Charles & Piazza, 2009; Gruenenfelder-Steiger et al., 2017; Koval et al., 2016; Niermann, Herrmann, von Haaren, van Kann, & Woll, 2016; Sandstrom, Lathia, Mascolo, & Rentfrow, 2017). Recent empirical work on the dynamic nature of affect takes context into account as a source of inter- and intraindividual variation (Adolf, Voelkle, Brose, & Schmiedek, 2017). In this study, we focus on how much pain a participant felt on a particular day and the level of impairment at that day as an important contextual information that might play a role in the participant's intraindividual variation of affect.

3.4.1.3 Association Between Pain and Affect

Cross-sectional results have shown that older adults who experience chronic pain report significantly lower health-related quality of life and satisfaction with life compared to older adults with no pain (Simsek et al., 2010; Willman et al., 2013). Similarly, dispositional optimism, meaning in life and mood have been shown to be related to less intense and less frequent experience of pain (Dezutter, Luyckx, & Wachholtz, 2015; Song, Graham-Engeland, Mogle, & Martire, 2015). Beyond concurrent associations, pain is often perceived as disruptive and may have longer lasting effects. For example, one longitudinal study found that chronic pain was related to depression 12 months later and that depression was related to a stronger pain experience 12 months later (Kroenke et al., 2011). These bidirectional effects are typically explained by the disability hypothesis arguing that pain results in affective distress and affective distress in turn influences physical health (Diefenbach, Leventhal, Leventhal, & Patrick-Miller, 1996).

Previous micro-longitudinal studies replicated the bidirectional association between pain and affect on the within-person level in middle-aged patient samples (Affleck, Urrows, Tennen, Higgins, & Abeles, 1996; Kothari, Davis, Yeung, & Tennen, 2015; Kwissa-Gajewska & Gruszczynska, 2018; Newth & Delongis, 2004; Shacham, Reinhardt, Raubertas, & Cleeland, 1983; Song et al., 2015; Zautra, Johnson, & Davis, 2005). Similar results were found in middle-aged and older age patient samples (Hamilton, Zautra, & Reich, 2005; Kratz, Mary, Davis, & Zautra, 2007). For example, a current daily diary study across 7 days reported a within-person association between daily pain and affect in a sample of 54 women (age 24 – 65 years) with rheumatoid arthritis (Kwissa-Gajewska & Gruszczynska, 2018).

However, pain experiences can also be part of the daily life of otherwise healthy older adults, and there is a lack of research examining the within-person association between pain and affect outside of the clinical context. In this study, we argue that the association between self-reported ratings of pain and affect in older age can be twofold. On the one hand, healthy older adults should report high levels of affect despite some minor pain in everyday life. At the same time, there should be a visible affective within-person association with the occurrence and intensity of pain in everyday life in most older adults. We assume that these bidirectional associations are not only concurrently observable, but that these effects should also be found in a time-lagged manner.

3.4.1.4 Health-Related Moderators in the Pain-Affect Association

Previous research has shown that protective factors such as optimism, perceived social support, and meaning in life influence the within-person association between pain and affect (Dezutter et al., 2015; Kwissa-Gajewska & Gruszczynska, 2018; Song et al., 2015). On the other hand, variables such pain catastrophizing, and neuroticism play a role in the within-person association between pain and affect (Affleck, Tennen, Urrows, & Higgins, 1992; Crombez, Viane, Eccleston, Devulder, & Goubert, 2013; Kratz et al., 2007; Wong et al., 2015). In particular, the fear-avoidance model of pain (Leeuw et al., 2007; Wong et al., 2015) argues that negative affect is associated with the pain experience in a vicious circle that is driven by a fear of pain. Avoiding situations because of this fear strengthens the bidirectional association between pain and affect. However, pain acceptance seems to be one of those predictive factors that dampens the association between pain and fearful thinking about pain (Crombez et al., 2013). A recent experience sampling study showed that moments with more intense pain, more fearful thinking about pain, and less positive emotions were also moments with increased attention to pain. Moreover, moments with more intense pain, more negative emotions, and less positive emotions were moments with increased fearful thinking (Crombez et al., 2013). Attention to pain because of this fear is likely to be associated with health-related variables. For example, individuals who report more subjective health and less health conditions pay also less attention to illness (Eriksen & Ursin, 2004). Identifying health-related variables as between-person moderators in the association between pain and affect would help to advance the understanding of underlying

differences between individuals as proposed in the fear and avoidance model (Leeuw et al., 2007), and could indicate possible avenues for intervention.

This research aims at looking not only at between-person moderators but also at time-varying variables that may function as within-person moderators as they more directly characterize the context (rather than the person) in which the pain-affect coupling takes place and unfolds. The difference being that within-person moderators focus on differential occasions (such as days) that shape the association between pain and affect in contrast to differences between individuals. In particular, within-person moderators would be informative about what kind of days (i.e., daily context characteristics) strengthen or weaken the within-person association between pain and affect. The investigation of such a within-person moderator would describe a more fine-grained picture of the within-person processes and therefore portray a more holistic picture of the pain-affect association in its diurnal rhythm. One specific health-related variable that is likely to be associated with attention to health or pain is the intensity of impairment one feels by his or her pain. Similar to the reasoning above, we argue that impairment is linked to a greater awareness of the pain and therefore more attention to pain itself. Thus, we assume that the association between pain and affect is strengthened on days with higher impairment of pain.

3.4.1.5 The Present Study

The present study was conducted in order to examine within-person dynamics of pain and affect in the daily lives of healthy older adults. Daily diary data over 21 days was used to answer four research questions: First, is greater pain on a given day related to less positive and more negative affect? Second, is there a temporal carry-over effect from yesterday's pain on today's affect? Third, are days with stronger perceived impairment also days with a stronger within-person association between pain and affect? Fourth, are there interindividual differences in the within-person association between pain and affect that can be explained in part by dispositional differences in health-related variables? Based on the theoretical reasoning above, this study targets the following hypotheses:

- *Hypothesis 1*: Individuals report increased pain on days with higher negative affect (and on days with lower positive affect).

- *Hypothesis 2*: Individuals report increased pain following days with higher negative affect (and lower positive affect).

- *Hypothesis 3*: The within-person association between pain and affect is especially pronounced on days with stronger perceived physical impairment than on days with less strong physical impairment.

- *Hypothesis 4*: The within-person association between pain and affect is especially pronounced in individuals with higher self-reported health and higher satisfaction with health than in individuals with lower self-reported health and lower satisfaction with their health.

3.4.2 Methods

3.4.2.1 Participants

Recruitment of healthy older adults was performed by distributing flyers and holding informational events in nursing homes in Zurich. The purpose of the study was advertised as examining quality of life of older adults. A total of 240 participants were recruited. In the early stage of the study, 16 participants quit the study due to the intensive nature of answering daily questionnaires. The final sample consisted of 224 individuals (56.7% female) aged 63 to 92 years ($M = 77.59$, $SD = 6.18$). Forty-eight percent of the individuals were married (39% widowed, 13% single). In terms of education, 7.2% received six years of schooling, 12% received nine years of schooling, 5.8% received twelve years of schooling. Twelve percent of the individuals completed an apprenticeship after schooling and 29.9% held a degree of a higher educational institution. Participants reported a good satisfaction with their health and few physical health conditions (see Table 10).

3.4.2.2 Procedure

The study was conducted according to the Declaration of Helsinki and in accordance with ethical principles of the Ethics Committee of the Faculty of Arts and Social Sciences of the University of Zurich. Participants received a set of paper-pencil-questionnaires at their homes and were asked to fill out these questionnaires daily during the following three weeks.

Table 10: *Means, Standard Deviations, and Between-Person Correlations Among Baseline and Aggregated Daily Variables*

Variable	*M*	*SD*	1	2	3	4	5	6	7
1. Mean daily PA	3.65	0.59							
2. Mean daily NA	1.77	0.54	-.56***						
3. Mean daily pain	2.05	0.83	-.35***	.40***					
4. Mean daily impairment	1.98	0.73	-.34***	.34***	.82***				
5. Physical conditions	1.83	1.76	-.28***	.23***	.56***	.53***			
6. Satisfaction with health	4.05	0.84	.46***	-.30***	-.54***	-.57***	-.58		
7. Age	77.59	6.18	-.10	.09	.03	.04	.14	.01	
8. Gender	0.57	0.50	-.08	.13	.20**	.18*	.11	-.08	.08

Note. $N = 224$. The correlations including the variable mean daily impairment were computed with $N = 205$ due to the fact that participants who answered to have not experienced any pain did not rate the follow-up item on daily impairment by pain. PA = positive affect, NA = negative affect. Gender: 1 = female. *$p < .05$. **$p < .01$. ***$p < .001$.

On the first day, participants completed a demographic questionnaire and answered items regarding their general health among other variables. From the next day on, participants filled out an evening questionnaire during 21 consecutive days, using a daily diary approach. This evening questionnaire contained items regarding participants' daily affect, daily pain and daily impairment. Participants were instructed to answer the daily items at the end of each day and were encouraged to leave the questionnaires unanswered rather than to fill them out retrospectively the next day (on average, the daily dairies were completed at 8pm, $SD = 2.3$ hours). Participants were randomly assigned to one of three groups with different tasks at the end of the day. One group had to write down five things for which they felt grateful for during the preceding day. Another group had to write down five things about their daily activities. The third group did not receive an additional task after the evening diary. In order to return a weekly set of questionnaires to the university, participants were provided with three stamped envelopes. All individuals provided informed consent prior to the study, participated voluntarily and did not receive monetary compensation for their effort. At the end of the study, participants received a feedback about the key results of the study and practical implications. Participants answered the item on daily positive affect on average on 20.42 days ($SD = 1.89$, 2.8% missing data) and the item on daily negative affect on average on 20.39 days ($SD = 1.93$, 2.9% missing data). Participants answered the item on daily pain on average on 20.37 days ($SD = 1.85$, 3% missing data) and the item on impairment on average on 20.83 days ($SD = 0.89$, 5.9% missing data). From the potential 4,704 daily measurement points (224 participants x 21 assessments) there were 4,543 observations (96.4%) obtained.

3.4.2.3 Daily Measures

Daily affect. Daily affect was measured with adjective-based items (Brunstein, 1999). Each of the 12 items started with "Today, I felt..." and ended with one of the six positive affect items (content, happy, confident, active, hopeful, energetic) or one of the six negative items (tired, disappointed, worried, anxious, sad, listless). Participants rated their daily affect on a 1 (*not at all*) to 5 (*extremely*) Likert-type scale. The within-person reliability of the scales was estimated following a G theory approach recommended by Bolger and Laurenceau (2013). The within-person reliability R_c of daily positive and negative affect

was .70 and .60, respectively.

Daily pain. Daily pain was measured with the single item "How much pain did you experience today?". The item was rated on a 1 (*not at all*) to 5 (*a lot*) Likert-type scale. Research has consistently demonstrated that a single item measure of pain is as reliable and valid as multiple item scales (Jensen, Karoly, & Braver, 1986; Kothari et al., 2015; Ong, Zautra, & Reid, 2010).

3.4.2.4 Health-Related Within-Person Moderator

Daily impairment. If participants indicated having experienced pain on a given day, they were asked to rate a follow-up item on their impairment by pain. The item "If you experienced pain today, how strongly did you feel impaired by your pain?" was rated on a 1 (*not at all*) to 5 (*a lot*) Likert-type scale.

3.4.2.5 Health-Related Between-Person Moderators

Physical health conditions. At baseline, interindividual differences in physical health conditions were measured by using a brief checklist about physical conditions (Brunstein, 1999). The checklist consisted of the following four items and used a dichotomous ("*yes/no*") response scale: "Did your physical health decline in the last five years?", "Are you in permanent treatment because of a physical disease?", "Does your pain impair your physical activity?" and "Are there longer periods of times without physical suffering?" (reversed). These four items, 0 for "no" and 1 for "yes", were summed up to a scale that ranged from 0 to 4. Internal consistency by means of Kuder-Richardson 20 was .83.

Satisfaction with physical health. At baseline, interindividual differences with regard to the general satisfaction with one's own physical health were assessed with the single item "How satisfied are you with your physical health" (Idler & Benyamini, 1997) with response options ranging from 1 *(not at all)* to 5 (*very much*).

3.4.2.6 Analytical Approach

The within-person association between daily pain and affect was examined using multilevel modeling. Multilevel models allow to compute individual intercepts and slopes for each participant and therefore to investigate both between-person and within-person asso-

ciations, accounting for the non-independence of errors due to several observations nested within participants (Bolger & Laurenceau, 2013). In our models, the between-person variables (physical conditions, satisfaction with health, and age) were grand-mean centered. Male gender was coded as zero and female gender was coded as one. We decomposed the daily independent variable (daily pain) into a between-person and a within-person component (cf. Bolger & Laurenceau, 2013). The between-person component was computed by subtracting the grand-mean from the person-mean. The within-person component was computed by subtracting the person-mean from the raw value. This decomposition was applied to control for between-person association and to examine within-person fluctuations from day-to-day. Ratings of the previous day were included to examine temporal lags (Wickham & Knee, 2013). The first lagged observation of a participant was always set to missing. In line with the concurrent variables, a within-person centered component of the lagged variables was used for the multilevel analyses. We also added a variable measuring time in study (centered at the first session) into the models to control for any linear time-related changes that are not the focus of this paper (cf. Bolger & Laurenceau, 2013). An autoregressive covariance structure (AR1) was implemented at the within-person level in order to control for auto-dependency between the time varying variables. Separate analyses for each of the three groups (see procedure) evidenced similar results as for the sample as a whole, indicating the lack of an intervention effect in our present analyses. Therefore, we addressed the fact of having three different groups in our data by adding dummy coded variables of the group membership as control variables in our final models.

As indicators of goodness of fit, we used the Akaike information criterion (AIC) and the Bayesian information criterion (BIC), evaluating the model with a lower value as the better model. Models with an AR1 structure showed better fit indices than models without an AR1 structure, the fit indices are as following: Positive affect model with AR1 structure (AIC = 4905.24, BIC = 5089.21), positive affect model without AR1 structure (AIC = 4978.84, BIC =5156.47). Negative affect model with AR1 structure (AIC = 4986.92, BIC = 5170.87), negative affect model without AR1 structure (AIC = 5050.52, BIC = 5228.12). Although no consensus occurs with respect to the appropriate effect sizes in multilevel modeling, we employed the strategy suggested by Peugh (2010) and report global pseudo-R^2 statistics. This measure of effect size quantifies the variance in the outcome variable

explained by all predictor variables in the multilevel model and can be computed in a similar way as the R^2 in multiple regressions (Peugh, 2010). The analyses of our multilevel models was conducted with the "nlme" package (Pinheiro, Bates, DebRoy, & Sarkar, 2017) in R (R Core Team, 2017) in order to model the autoregressive structure of our data.

The multilevel model for the daily association between pain and affect is formally represented in the following two equations. For reasons of parsimony, we illustrate this example with three control variables (mean pain, age and gender) instead of the full models with more control variables. The first equation represents the within-person association:

Level 1:

$$Y_{ij}\text{Affect} = \beta_{0j} + \beta_{1j}\text{Affect}_{(t-1)ij} + \beta_{2j}\text{Pain}_{(t-1)ij} + \beta_{3j}\text{Pain}_{(t)ij} + \beta_{4j}\text{Time}_{ij} + \varepsilon_{ij}$$

Y_{ij} represents daily affect for each person j on day i. β_{0j} represents the initial within-person level of daily affect for each person j, β_{1j} denotes the within-person slope between daily affect and time-lagged affect for each person j, β_{2j} denotes the within-person slope between daily affect and time-lagged pain for each person j, β_{3j} denotes the within-person slope between daily affect and the concurrent daily pain for each person j, β_{4j} denotes the linear within-person association between daily affect and time for each person j and ε_{ij} represents the residual within-person variance. The second equation represents the between-person associations:

Level 2:

$$\beta_{0j} = \gamma 00 + \gamma 01(\text{person-mean pain}_j) + \gamma 02(\text{age}_j) + \gamma 03(\text{gender}_j) + u_{0j}$$
$$\beta_{1j} = \gamma 10 + \gamma 11(\text{person-mean pain}_j) + \gamma 12(\text{age}_j) + \gamma 13(\text{gender}_j) + u_{1j}$$
$$\beta_{2j} = \gamma 20 + \gamma 21(\text{person-mean pain}_j) + \gamma 22(\text{age}_j) + \gamma 23(\text{gender}_j) + u_{2j}$$
$$\beta_{3j} = \gamma 30 + \gamma 31(\text{person-mean pain}_j) + \gamma 32(\text{age}_j) + \gamma 33(\text{gender}_j) + u_{3j}$$
$$\beta_{4j} = \gamma 40 + \gamma 41(\text{person-mean pain}_j) + \gamma 42(\text{age}_j) + \gamma 43(\text{gender}_j) + u_{4j}$$

$\gamma 00$, $\gamma 10$, $\gamma 20$, $\gamma 30$ and $\gamma 40$ represent the average within-person intercept and average within-person slopes of the time-lagged affect, time-lagged pain, concurrent pain, and time. $\gamma 01$, $\gamma 11$, $\gamma 21$, and $\gamma 31$ and $\gamma 41$ represent the between-person association between

average daily affect and average daily pain in the intercept and the four slopes. $\gamma 02$, $\gamma 12$, $\gamma 22$, $\gamma 32$ and $\gamma 42$ represent the between-person association between average daily affect and age. $\gamma 03$, $\gamma 13$, $\gamma 23$, $\gamma 33$ and $\gamma 43$ represent the between-person association between average daily affect and gender. u_{0j}, u_{1j}, u_{2j}, u_{3j}, and u_{4j} are residual between-person variances of the intercept and the slopes. This between-person equation is an exemplary equation with the between-person control variable mean pain, age and gender. However, we added further between-person control variables (physical health conditions, satisfaction with health, dummy variables of the assigned groups) to our analyses. All intercepts and slopes were modeled as random effects (Bolger & Laurenceau, 2013).

3.4.3 Results

Out of the total amount of days, 62% of all observations (N = 4,704) were rated by the participants as days with pain. These 62% of observations were rated with a value higher than 1 on a scale ranging from 1 to 5. The value 1 was labeled as "Today, I did not experience any pain at all", the value 2 was labeled as "Today, I experienced a little bit of pain". A more detailed analysis showed that an average person experienced 12.4 days with at least a little bit of pain (SD = 8.43) out of the 21 days. Thirty-two participants showed no variance in their rating of pain (14.3%). Twenty-nine out of these 32 participants reported no experience of pain at all over the course of the study (90.6%).

The descriptive results are reported in Table 10. Between-person correlations represented by aggregated daily scores showed that mean daily positive affect was negatively associated with mean daily negative affect, mean daily pain, mean daily impairment and general physical health conditions. However, mean daily positive affect was positively associated with baseline satisfaction with health. Mean daily negative affect was positively associated with mean daily pain, mean daily impairment and general physical health conditions but negatively associated with baseline satisfaction with life. General physical health conditions were positively associated with both mean daily pain and mean daily impairment. There were no statistically significant baseline associations between the variables of interest and gender and age except for a positive association between female gender and general physical health conditions and mean daily impairment. As expected, the highest positive correlation was found between mean daily pain and mean daily impairment.

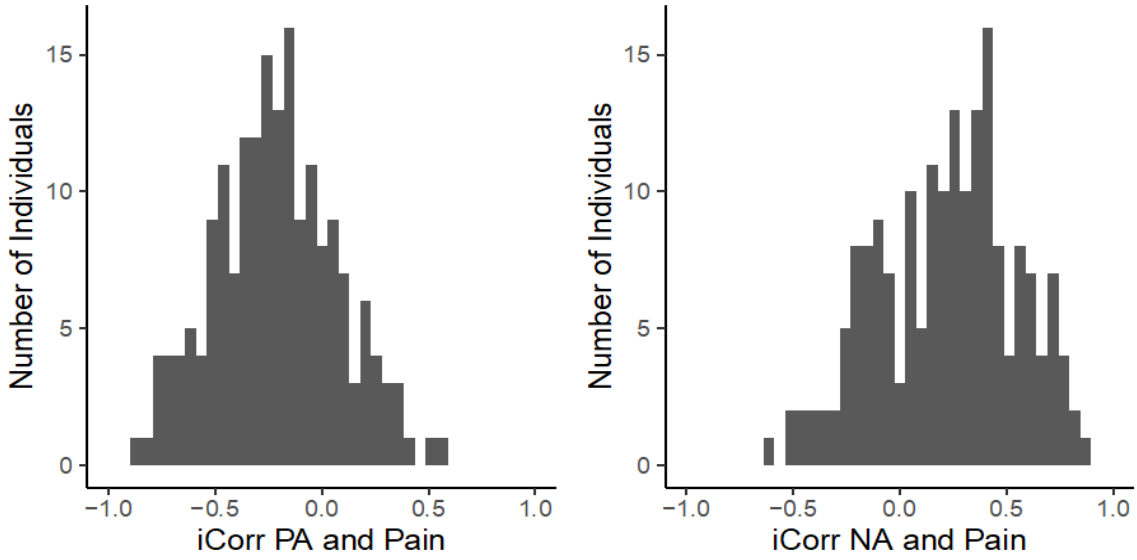

Figure 6: Individual within-person correlations (iCorr) between daily positive affect (PA) and daily physical pain (left figure), and between daily negative affect (NA) and daily physical pain (right figure).

Intraclass correlations (ICC) showed 64% (daily positive affect), 59% (daily negative affect), 67% (daily pain) and 57% (daily impairment) between-person variance with regard to the total variance, hence indicating substantial levels of within-person variability in all three variables (i.e., ranging between 33% to 43%). Individual within-person correlations (iCorr) were computed to investigate associations within participants in contrast to relations between participants (Hülür, Hoppmann, Ram, & Gerstorf, 2015). Distributions of the iCorrs are illustrated in Figure 5. Within-person correlations showed consistently weaker effect sizes in comparison to between-person correlations but were in the same direction. The within-person correlation between daily pain and daily positive affect was r = -.22 (on the between-person level r = -.35) and the within-person correlation between daily pain and daily negative affect was r = .21 (on the between-person level r = .40). The within-person correlation between daily pain and daily impairment was r = .66 (on the between-person level r = .82).

3.4.3.1 Concurrent and Time-Lagged Relations Between Daily Pain and Positive Affect

Multilevel results (Table 11) corroborated the results based on iCorrs briefly reported above. Daily pain was negatively associated with concurrent daily positive affect (b = -

0.17, $SE = 0.02$, $p < .001$) but not with respect to the time-lagged variable. In other words, yesterday's pain was not significantly associated with today's positive affect. Results imply that days with higher pain were associated with days with lower positive affect within the average person even after controlling for between-person differences in mean pain. Moreover, individuals with higher satisfaction with health reported higher daily positive affect. However, due to the correlational nature of multilevel models, these results do not allow interpretation about the causality of these effects (Gelman, 2006).

3.4.3.2 Concurrent and Time-Lagged Relations Between Daily Pain and Negative Affect

Results showed that both concurrent within-person daily pain ($b = 0.18$, $SE = 0.02$, $p < .001$) and time-lagged ratings of pain ($b = 0.03$, $SE = 0.01$, $p = .01$) were positively associated with daily negative affect within the average person even when controlling for mean-level differences in daily pain, baseline physical health conditions, baseline satisfaction with health, age, gender, time, assignments to different groups and the autoregressive structure of the data. This indicates that days with higher pain were associated with days characterized by higher negative affect. Moreover, yesterday's pain was positively associated with today's negative affect but not vice versa (Table 11).

3.4.3.3 Within-Person Moderators of the Within-Person Association Between Daily Pain and Affect

Next, we tested daily impairment as a potential within-person moderator. To do so, we used a subsample of observations in which we excluded all observations rated with no pain at all, resulting in $N = 2{,}920$ observations, representing 62% of the total sample. The subsample was created because participants did not answer a follow-up item on impairment if they indicated having not experienced any pain at all this particular day. The within-person moderation analyses showed that days on which individuals felt more strongly impaired by their pain were days with a stronger within-person association between pain and affect in contrast to days on which participants felt less strongly impaired by their pain (Table 12). A stronger within-person association was found for both positive and negative affect. Figure 6 shows an illustration of these results by plotting data of – 1SD

Table 11: *Concurrent and Time-Lagged Within-Person Coupling Between Daily Physical Pain and Affect*

	Daily positive affect				Daily negative affect			
			CI_{95}				CI_{95}	
	Estimate	*SE*	Upper	Lower	Estimate	*SE*	Upper	Lower
Fixed Effects								
Intercept	3.64***	0.07	3.47	3.78	1.77***	0.07	1.63	1.93
Daily affect$_{t-1}$	-0.17***	0.02	-0.21	-0.14	-0.18***	0.02	-0.23	-0.14
Daily pain$_{t-1}$	-0.02	0.01	-0.05	0.01	0.03*	0.01	0.01	0.06
Daily pain	-0.17***	0.02	-0.20	-0.14	0.18***	0.02	0.14	0.22
Mean pain	-0.09	0.05	-0.20	0.01	0.21***	0.05	0.10	0.30
Physical conditions	0.02	0.03	-0.05	0.08	-0.01	0.03	-0.06	0.06
Satisfaction with health	0.29***	0.06	0.18	0.40	-0.09	0.05	-0.19	0.02
Age	-0.01	0.01	-0.02	0.00	0.01	0.01	0.00	0.02
Gender	<0.01	0.07	-0.15	0.14	0.05	0.07	-0.09	0.19
Time	<0.01	< 0.01	-0.01	<0.01	-0.01*	< 0.01	-0.01	0.00
Random Effects								
Intercept	0.51***				0.51***			
Daily affect$_{t-1}$	0.13***				0.17***			
Daily pain$_{t-1}$	0.07				0.07			
Daily pain	0.15***				0.18***			
Time	0.01***				0.02***			
Residuals	0.41				0.41			

Note. Number of observations in model with daily positive affect = 4,217. Number of observations in model with daily negative affect = 4,212. All models controlled for group membership which did not emerge as a significant predictor. t-1 indicates the time-lagged variable (e.g., yesterday's pain). Coefficients shown are unstandardized coefficients. *SE* represents the standard error of the unstandardized regression coefficients.
*$p < .05$. **$p < .01$. ***$p < .001$

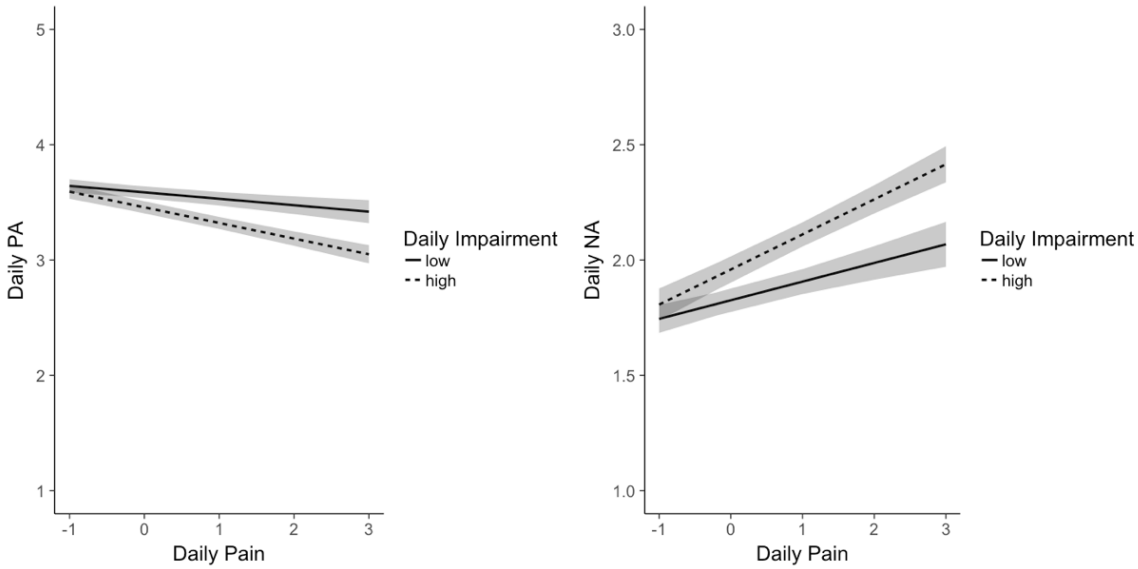

Figure 7: Daily impairment as a within-person moderator of the within-person association between daily physical pain and affect. Days without physical pain were excluded).

and + 1SD of the continuous moderator variable (daily impairment).

3.4.3.4 Between-Person Moderators of the Within-Person Association Between Daily Pain and Affect

The iCorr values described above and illustrated in Figure 5 showed that there seem to be between-person differences in the strength of the within-person associations with daily pain and affect. Therefore, we also explored three potential between-person moderators in terms of individual differences (i.e., general health conditions, general satisfaction with health and chronological age). Models of individual differences were again computed with the total sample of N = 4,707. General health conditions were found to be a between-person moderator in the within-person association between daily pain and negative affect (b = 0.03, SE = 0.01, p = .003) but was not a between-person moderator in the within-person association between daily pain and positive affect (p = .192). Stronger within-person associations in daily pain and negative affect were found in individuals with stronger negative health conditions in contrast to individuals with less negative health conditions. Also, satisfaction with health was found to be a between-person moderator in the within-person association between daily pain and affect for both positive (b = 0.05, SE = 0.02, p = .003) and negative affect (b = -0.09, SE = 0.02, p < .001). Even though individuals with higher

and lower general satisfaction with their health showed a similar slope in their within-person associations between daily pain and affect, individuals with higher satisfaction with health showed more daily positive affect despite pain in contrast to individuals with lower satisfaction with their health. When looking at daily negative affect, results showed that individuals with lower satisfaction with their health had stronger within-person associations between daily pain and affect than individuals with higher satisfaction with their health (Table 12). All individual differences results are illustrated in Figure 7. Chronological age was not found to be a between-person moderator, neither for the pain-positive affect ($p = .976$) nor for the pain-negative affect ($p = .998$) association.

3.4.4 Discussion

The aim of this study was to examine intra- and interindividual differences in the within-person association between daily pain and affect in the everyday life of healthy older adults. Results showed that 62% of all obtained assessments ($N = 4{,}704$) were days with pain, indicating that the experience of pain is quite common in the daily life of healthy older adults. Consistent with previous research, older adults showed relative high levels of daily positive affect and low levels of daily negative affect (e.g., Carstensen et al., 2011; Röcke et al., 2009). Days with increased pain were days with lower levels of emotional well-being, indicated by less positive and more negative affect within the average person. Time-lagged results showed that moreover, pain of the previous day was positively associated with today's negative affect but not with today's positive affect. On days on which older adults felt more strongly impaired by their pain, they reported a more pronounced within-person association between daily pain and affect in comparison to days with a less strong experience of impairment. Interindividual differences in these associations were found with regard to general health conditions and general satisfaction with health but not with regard to chronological age.

3.4.4.1 Associations Between Daily Pain and Daily Affect

The main results obtained in this study are in line with previous micro-longitudinal findings of middle-aged patient samples (Affleck et al., 1996; Charles & Almeida, 2006; Kothari et al., 2015; Kwissa-Gajewska & Gruszczynska, 2018; Newth & Delongis, 2004;

Table 12: *Daily Impairment as a Within-Person Moderator in the Within-Person Coupling Between Daily Physical Pain and Affect*

	Daily positive affect				Daily negative affect			
			CI_{95}				CI_{95}	
	Estimate	*SE*	Upper	Lower	Estimate	*SE*	Upper	Lower
Fixed Effects								
Intercept	3.61***	0.09	3.44	3.78	1.73***	0.09	1.56	1.90
Daily pain	-0.10***	0.02	-0.14	-0.05	0.12***	0.03	0.07	0.17
Daily impairment	-0.10***	0.02	-0.14	-0.06	0.10***	0.02	0.06	0.14
Mean pain	-0.02	0.09	-0.19	0.15	0.25**	0.08	0.08	0.41
Mean impairment	-0.13	0.10	-0.33	0.06	0.07	0.10	-0.12	0.25
Physical condition	0.03	0.03	-0.03	0.08	-0.02	0.03	-0.07	0.04
Satisfaction with health	0.26	0.06	0.14	0.37	-0.06	0.06	-0.17	0.06
Age	-0.01	0.01	-0.02	<0.01	0.01*	0.01	<0.01	0.03
Gender	-0.03***	0.08	-0.18	0.12	0.04	0.08	-0.11	0.19
Time	<0.01	<0.01	-0.01	<0.01	<0.01	<0.01	-0.01	<0.01
Daily pain X daily imp	-0.06***	0.02	-0.10	-0.03	0.05**	0.02	0.02	0.09
Mean pain X daily imp	0.08	0.07	-0.07	0.22	-0.06	0.07	-0.20	0.08
Random Effects								
Intercepts	0.49***				0.53***			
Daily pain	0.11				0.16			
Daily impairment	0.12				0.14			
Time	0.02				0.02			
Residuals	0.41				0.40			

Note. Number of observations in model with daily positive affect = 2,690. Number of observations in model with daily negative affect = 2,684. Moderation analysis was performed with observations that contained days with physical pain. All models controlled for group membership which did not emerge as a significant predictor in the models. t-1 indicates the time-lagged variable (e.g., yesterday's pain). Imp = impairment by one's own physical pain. Coefficients shown are unstandardized coefficients. *SE* represents the standard error of the unstandardized regression coefficients. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

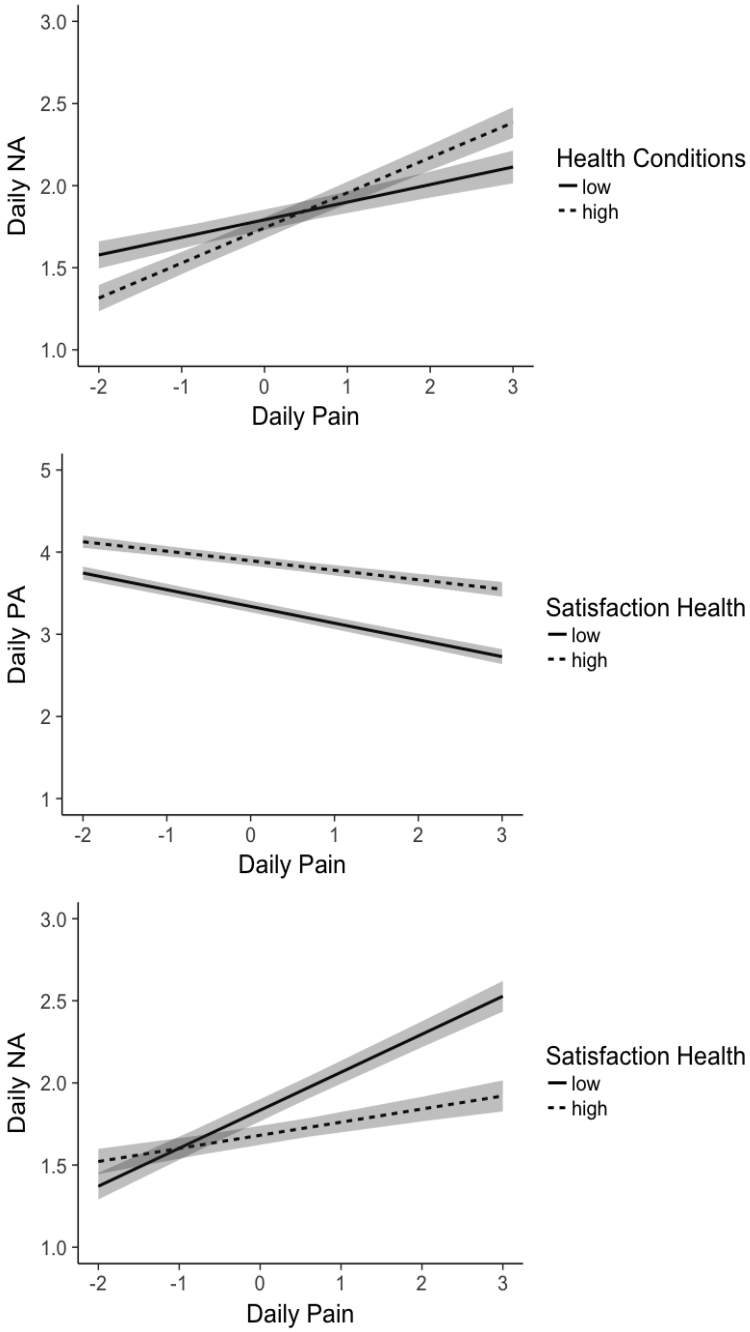

Figure 8: Between-person moderators in the within-person association between daily physical pain and affect.

Zautra et al., 2005) and older adult patient samples (Kratz et al., 2007). The results of this study indicate that pain-affect associations portray in a very similar way even when it comes to mild to moderate pain levels in an otherwise healthy sample of older adults. As minor pain may reflect a substantial part of most older adults' everyday lives (Gibson & Lussier, 2012; Patel et al., 2013), it is important to understand how the maintenance of emotional well-being unfolds in everyday life despite the pain, but in the absence of chronic pain levels. In support of our first hypothesis, an increase in daily pain was related to an increase in daily negative affect and a decrease in daily positive affect. These results depicted that even though healthy older adults show relatively high levels of emotional well-being (in terms of high mean daily positive and low mean daily negative affect), their everyday lives are affected by pain. According to the biopsychosocial model, the experience of pain is seen as a result of biological, psychological and socio-cultural factors (Gatchel et al., 2007). The present study showed that the individual evaluation of one's own pain is significantly associated with psychological constructs such as the daily affective experience. However, the directionality of effects of multilevel modeling results must be interpreted with caution as the correlational nature of these analyses does not allow causal inference (Gelman, 2006).

To further disentangle the within-person association between daily pain and daily affect, we extended our analysis of concurrent relations to time-lagged associations of pain and affect. The temporal structure of our data enabled us to study temporal carry-over effects from the previous day on the present day (Wickham & Knee, 2013). As postulated in hypothesis 2, we were interested in the affective responding to pain of older adults after a day with increased negative or positive affect. Interestingly, we found differential effects for daily positive and daily negative affect. Yesterday's pain was associated with today's negative affect but not with today's positive affect. The temporal carry-over of pain on daily affect appears to differ between positive and negative affect. Previous research has shown inconsistent time-lagged findings of within-person associations between daily pain and daily affect in chronic patient samples (Affleck et al., 1991; Affleck, Tennen, Urrows, & Higgins, 1994; Feldman, Downey, & Schaffer-Neitz, 1999; Hamilton et al., 2005; Ivey, Allen, Liu, Parmelee, & Zarit, 2018) but has also provided evidence for stronger implications of negative over positive experiences for various psychological domains (Baumeister,

Bratslavsky, Finkenauer, & Vohs, 2001).

3.4.4.2 Differential Within-Person Associations Between Daily Pain and Daily Affect

In support of our third hypothesis, results displayed that a feeling of being more strongly impaired by one's pain made individual even more vulnerable to the negative effects of pain on affect. Days with a stronger experience of impairment were days with a stronger within-person association between pain and affect in contrast to days with a less strong experience of impairment. Even though the within-person correlation between pain and feeling impaired by pain was as expected to be very high (r = .66), results showed different patterns with regard to low versus high daily impairment. These results indicate that older adults manage to maintain affective stability despite pain on days when they do not feel impaired by it. Possibly, impairment fosters the awareness of pain and therefore individuals pay more attention to affect and pain on days when feeling stronger impaired. Impairment could also lead to catastrophizing of the fear of pain and therefore pain is more salient on days with higher impairment. Further examination of within-person moderators is needed to better understand these processes and to extend the theoretical model on fear-avoidance of pain (Leeuw et al., 2007). An alternative explanation for a stronger within-person association between pain and affect on days with higher impairment could be that those days require a different type of emotion regulation strategy. It remains unclear how the perception of impairment is related to different coping strategies or whether the feeling of impairment assessed in this study is part of a cognitive process to cope with pain (Novy, Nelson, Hetzel, Squitieri, & Kennington, 1998).

With regard to our fourth hypothesis about individual differences, we found mixed results. Previous research has examined the role of pain acceptance, neuroticism, optimism, quality of sleep, perceived social support and occurrence of major life stressors as between-person moderators (Affleck et al., 1996; Kothari et al., 2015; Kratz et al., 2007; Kwissa-Gajewska & Gruszczynska, 2018). Between-person moderators help to depict a more holistic picture of the biopsychosocial model which posits that multiple factors contribute to the pain experience. On the one hand, health conditions and chronological age are part of the biological aging process and on the other hand satisfaction with health

and everyday affect are psychologically meaningful variables of the model (Keefe, Lumley, Anderson, Lynch, & Carson, 2001). General health conditions were found to play a significant role in the within-person association between daily pain and negative affect but not in the within-person association between daily pain and positive affect. Individuals with stronger health conditions had a stronger within-person association between daily pain and negative affect. General life satisfaction moderated the within-person association between daily pain and both negative and positive affect. Individuals with higher satisfaction with their health showed consistently higher levels of daily positive affect regardless of their pain in contrast to individuals with lower satisfaction with their health. So far, little research has explicitly looked at factors that could promote higher positive affect and most of the literature examining the link between pain and affect has focused on negative affect. Results showed that individuals with lower satisfaction with health had a stronger within-person association between daily pain and negative affect than individuals with higher satisfaction with their health. In our sample of healthy older adults, the within-person association between daily pain and affect showed no individual differences with regard to chronological age despite the large age range from 63 to 92 years. These results imply that general health conditions and general satisfaction with health rather than chronological age per se seem to be important factors for interindividual differences in the pain-affect dynamics in daily life. These results can be interpreted in light of the fear and avoidance model insofar that individuals with better self-reported health have less reason to fear pain and therefore do not engage in a vicious circle of avoiding situations that could potentially lead to pain. A potential explanation is that individuals with higher self-reported health have more resources to deal with daily struggles as experiencing physical pain and might be better in coping with emotionally challenging situations, thus the weaker within-person association between pain and affect.

3.4.4.3 Limitations and Future Directions

The present work has several limitations that may guide future research. First, it remains unclear whether the within-person and between-person moderators found in this study also influence the lagged relationship between pain and affect. Future research with more intense sampling and therefore a higher power to investigate moderating effects in

lagged associations should address this limitation by replicating our results and investigating further temporal dynamic patterns. Moreover, little is known about how the interplay between daily pain and daily affect influences long-term well-being. Examining the same group of individuals over a longer period of years would help answering questions about the developmental interplay between pain and affect and their short-term dynamics (Röcke & Brose, 2013). Eventually, these short-term fluctuations could be linked to long-term outcomes such as well-being, life satisfaction and healthy aging. In particular, a measurement-burst design would help to connect findings from the micro timescale and the macro timescale (Nesselroade & Schmidt McCollam, 2000; Sliwinski, 2008).

Second, this study particularly used single items or short item scales to assess the variables of interest to not overburden participants with lengthy questionnaires. One limitation of daily diary studies is that researchers need to develop time efficient ways of measuring the constructs of interest to minimize the burden the participants. However, there is evidence for both single item scales and short item scales to show sufficient reliability and validity (Idler & Benyamini, 1997; Kothari et al., 2015; Wilhelm & Schoebi, 2007). Future research should further develop suitable short measurement of daily impairment that is distinct from pain and that can be used in daily diary and experience sampling studies.

Third, this study used paper-and-pencil diaries, which did not offer objective time stamp information on when the diary was actually filled in. Although participants were asked to complete their daily diary every night before going to bed and instructed not to do it the next day, there is no objective assurance that participants followed this instruction. However, participants indicated each evening at what time they filled out the questionnaire. Older adults are more conscientious regarding study adherence than younger adults (Park et al., 1999; B. W. Roberts & Mroczek, 2008) and there are reasons to believe that older adults feel more comfortable in participating in a paper-pencil study than a smartphone study. Moreover, previous research has shown that participants who agreed in participating in a daily diary study provide data that is very comparable to studies using electronic diaries (Green et al., 2006).

Fourth, to test our hypotheses we made use of data from an intervention study with three different groups. However, in our analyses we statistically controlled for the group memberships and also ran the main analyses separately for each of the three groups. Future

research should replicate our findings using other study designs.

Finally, keeping the biopsychosocial model in mind, we recognize that the within-person association between daily pain and affect is complex in its nature and that there might be other factors contributing to the strength of this association. The experience of pain may vary as a function of genetic factors, prior learning, current psychological status, sociocultural influences, environmental parameters and the particular lifestyle of participants, including their social activities and social support (Gatchel et al., 2007; Keefe et al., 2001; Lumley et al., 2011). In this paper, we focused primarily on subjective health and psychological variables as part of the biopsychosocial model. Future research should also include biological variables and more social variables such as type of activities in daily life and interpersonal relationships.

In summary, this research can point to fruitful future directions. In light of the changing demographic landscape, the care of and for older adults will increasingly gain importance. There are clinical studies that support mindfulness interventions as a possible way to cope with pain (Cassidy, Atherton, Robertson, Walsh, & Gillett, 2012; Day, Jensen, Ehde, & Thorn, 2014; Ussher et al., 2014). However, feeling pain in older age is also a normative process that is unlikely to be evitable. Future intervention studies should focus on how acceptance of pain influences affect in everyday life. For example, acceptance and commitment therapy seems a promising intervention to decrease both pain and affect (Loebach Wetherell et al., 2011; McCracken & Vowles, 2014). A daily diary study reported that the association between pain intensity and fearful thinking about pain was weaker in individuals with higher acceptance of their pain in contrast to individuals with lower acceptance values (Crombez et al., 2013). The potential of acceptance of pain as well as other person- and context-level variables is yet to be investigated in a sample of older adults outside of the clinical context. Just because pain may belong to many older adults' daily life experiences does not mean that the search for coping facilitators should not be undertaken.

3.4.4.4 Conclusion

With this work we were able to answer four research questions. First, days with more pain were days with more negative affect and less positive affect. Second, yesterday's pain was associated with today's negative affect but not today's positive affect. Third, days with

a stronger experience of impairment showed a stronger within-person association between pain and affect than days with a weaker experience of impairment. Fourth, individual differences in the within-person association between daily pain and affect were found with regard to general health conditions and general satisfaction with health. As the everyday lives of older adults are shaped by variability in both pain and affect, these results highlight the importance to investigate both between-person as well as within-person differences in the interplay between pain and affect above and beyond patient samples.

3.4.4.5 Author Contribution

Marko Katana wrote this manuscript and analyzed the data. Christina Röcke and Mathias Allemand provided feedback on the manuscript.

3.5 Article V: Physical Activity and Depressive Mood in Daily Life of Older Adults

Andrea E. Gruenenfelder-Steiger[1], **Marko Katana**[2,3], Annika A. Martin[2,3], Damaris Aschwanden[2,3], Julia L. Koska[4], Yvonne Kündig [1], Eliane Pfister-Lipp [1] Mathias Allemand[2,3]

[1] Institute Neumuenster, Zollikerberg, Switzerland

[2] Department of Psychology, University of Zurich, Zurich, Switzerland

[3] University Research Priority Program (URPP) "Dynamics of Healthy Aging", University of Zurich, Zurich, Switzerland

[4] Department of Psychology, University of Nuremberg, Nuremberg, Germany

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Abstract

Empirical evidence suggests that physical activity is related to less depressive mood. However, little is known about this association in everyday life of older adults, limiting the ecological validity of prior findings. The goal of this study was to examine within-person associations between physical activity and depressive mood in older adults across seven days. Moreover, the study tested the extent to which need-fulfillment can explain this association. The sample consisted of 68 adults aged 65 to 93 years. Physical activity was assessed objectively with accelerometers, whereas need-fulfillment and depressive mood were assessed at the end of each day using self-reports. Results from multilevel analysis suggest that daily physical activity was negatively related to daily depressive mood within-persons. Although need-fulfillment did not explain the association between physical activity and depressive mood, it was a statistically significant predictor of daily depressive mood and even attenuated the effect of physical activity on depressive mood to non-significance.

3.5.1 Introduction

3.5.1.1 Physical Activity and Depressive Mood in Daily Life of Older Adults

The growing group of older and very old people may be particularly vulnerable to depressive symptoms, as most of the risk factors such as low economic status, poor physical health, disability, and social isolation may apply for many of them (Bruce, 2002). Indeed, studies have shown that the prevalence of depressive symptoms tends to increase with age (Kennedy, 1996). Therefore, identifying factors that prevent mental illness and promote health and well-being in old age is an important goal for the individual and aging research. Physical activity is one promising candidate, as it is often conceptualized as a resource for a healthy and satisfying lifestyle that serves as a valuable protective factor against mental illness (Warburton, Nicol, & Bredin, 2006). The present study examined the association between physical activity and depressive mood in daily life of older adults. Whereas clinical depression is a severe psychological disorder, non-clinical depressive mood refers to varying states of increased negative affect that fluctuate within individuals over shorter time periods (World Health Organization, 2017). Depressive mood typically involves affective, cognitive and physiological symptoms (e.g., weakened activity, suspensions to be actively engaged in life, sadness) that can change from day to day, as people likely experience days with more and days with less depressive mood. In discussing previous research, we use the original terms (e.g., depressive mood, depressive symptoms, and depression) from the published work.

3.5.1.2 Definition and Assessment of Physical Activity

Physical activity is an umbrella term that combines different categories of body movements. Elements of physical activity are defined by Caspersen, Powell, and Christenson (1985) and include bodily movement via skeletal muscles that results in energy expenditure and is positively correlated with physical fitness. Exercise, in contrast, involves planned, structured and repetitive bodily movements and has the objective to improve or maintain physical fitness (Caspersen et al., 1985). So far, most of the research focused on physical activity during leisure time and exercising (Kanning & Schlicht, 2010). However, physical

activity may not only involve playing sports or engaging in exercise at a high level of intensity but also covers low intensity level activities such as cleaning, gardening or walking from A to B (Kanning, Ebner-Priemer, & Schlicht, 2013). Indeed, common categorizations of physical activity show a distinction into sleeping, activities at work, and leisure activity, but other forms such as weekdays versus weekend activities have been used as well (Caspersen et al., 1985). For the present research, we were particularly interested in activities of daily living (ADL) that represent physical activity in everyday life (Kanning et al., 2013). High physical functioning in terms of ADL has been proposed as an important factor for well-being and satisfaction (Sato, Demura, Kobayashi, & Nagasawa, 2002). Physical activity in everyday life typically includes activities that are performed to achieve an intended purpose, such as walking to the supermarket or to the bus station, or doing gardening (Kanning et al., 2013).

Physical activity can be assessed with self-report measures including questionnaires, diaries/logs, surveys, and interviews. These measures are frequently used due to their practicality, low cost, low participant burden, and general acceptance. Although self-reports are useful for gaining insight into the levels of physical activity, they have the capacity to over- and underestimate true physical activity, energy expenditure, and rates of inactivity (Sallis & Saelens, 2000). Moreover, self-reports of physical activity suffer from issues of recall and response bias (e.g., inaccurate memory, social desirability) and the inability to capture the absolute level of physical activity. Alternatively, objective and direct measures of physical activity (e.g., accelerometer or step counts) are commonly used to increase precision and accuracy (Ward, Evenson, Vaughn, Rogers, & Troiano, 2005). Hence, physical activity might be best measured (a) continuously as part of one's everyday normal routine in order to catch one's unbiased level of daily general activity and body movements, and (b) by means of an objective and unobtrusive measure in order to avoid omitting important activity information.

Despite the benefits of objective and direct measures of physical activity, only a few studies have placed emphasis on real-life daily activities in old age (Cheung, Gray, & Karunanithi, 2011). For example, a study investigated how much time six older adults spent sitting (79%), standing (77%), lying (91%) and walking (98%) for a period of 2-3 months (Allan & Johnson, 2009). Another study examined active and passive movements

in 47 older men (mean age 73.9 years) over 2 to 12 hours without being able to differentiate between standing and walking (C. Brown, Roth, & Allman, 2008). Thus, everyday activities across some days or even weeks might reflect an individual's physical activity level more realistically. So far, less is known about the protective effects of physical activity on depressive mood of older adults in daily life.

3.5.1.3 Physical Activity and Depressive Mood

A large body of epidemiological research shows a clear negative link between physical activity and depressive symptoms – besides a number of positive associations with people's health status (e.g., Harris, Cronkite, & Moos, 2006; Strawbridge, Deleger, Roberts, & Kaplan, 2002). A systematic review of prospective studies examined the relationship between physical activity and the prevention of depression (see Mammen & Faulkner, 2013, for a review). Of the reviewed studies, 83% indicated that physical activity is associated with a lower risk for the onset of a depression. As an example, higher walking levels are associated with a decreased risk of depressive mood of up to nearly 60% (Mammen & Faulkner, 2013). The reviewed studies consisted of non-clinical community samples across all age groups from 11 to 100 years in North America and Europe. Only one of the reviewed studies, however, objectively measured physical activity by using ergometer cycling. Most studies measured physical activity by asking participants how many minutes per week or day they had been physically active. Furthermore, Bernaards, Jans, Van Den Heuvel, Hendriksen, and Houtman (2006) investigated the longitudinal relation between strenuous leisure time physical activity and psychological complaints in a Dutch working population in a 3-year follow-up study. For workers with sedentary jobs, leisure time physical activity (1-2 times per week) was associated with a reduced risk of future depressive mood in workers aged 18 to 59 years. Leisure time physical activity was measured through self-report measures. Moreover, a longitudinal study of middle-aged women with three surveys across 5 years found a negative relationship between physical activity and depressive symptoms, independent of pre-existing physical and psychological health (W. J. Brown, Ford, Burton, Marshall, & Dobson, 2005). Self-report measures were used assess time spent in walking, moderate and vigorous intensity physical activity and psychological health.

The negative association between physical activity and depressive symptoms were also

evidenced in samples of older adults. For example, older adults (N = 663) aged 65+ participated in an eight-year study with two measurement occasions that examined changes in intensity of physical activity as predictors of depressive symptoms (Lampinen, Heikkinen, & Ruoppila, 2000). Results suggest that those participants with reduced intensity of physical activity during the eight years reported more depressive symptoms at the second measurement occasion. Older people who reduced the amount of walking had a 5.38 times higher risk of experiencing symptoms of depression. A meta-analysis investigated the association between physical activity and symptoms of depression in old age (Teychenne, Ball, & Salmon, 2008). A total amount of 27 observational and 40 intervention studies were included, and most of them showed a significant effect of physical activity on depression.

Despite the growing number of studies demonstrating associations between physical activity and depressive symptoms, less is known about whether and to what degree within-person variations in physical activity are related to within-person variations in depressive mood in everyday life. Previous work mostly relied on cross-sectional data, intervention data, prospective longitudinal data over longer time periods, and typically used self-reported measures of physical activity or focused on physical activity during leisure time and exercising (Kanning & Schlicht, 2010; Mammen & Faulkner, 2013; Teychenne et al., 2008). Moreover, previous research typically focused on between-person analyses, suggesting that higher levels of physical activity are associated with a lower risk of developing depressive symptoms. However, people differ both in their level of activity and depressive mood across days, weeks and months. That is, people do not only differ between each other on how physically active they are in general, but people also differ within themselves, that is, their physical activity differs from day to day. For example, a person might be moderately active during a typical week (e.g., perform one hour of intensive cycling per week and casually uses the bike). It would be interesting to see whether that person's variation in activity influences her or his daily depressive mood. Is this person feeling less depressed on days during which she or he experienced more activity compared to days when she or he was inactive? This question is interesting independent of how active the person is compared to the general population. Therefore, it would be very important to know whether and to what degree physical activity is related to depressive mood within individuals. Such knowledge would be fruitful to identify how these constructs are linked to each other and

provide us with valuable information for intervention strategies in everyday life. Instead of grouping people into more or less active groups, we aimed at relating within-person variations in physical activity to within-person variations in depressive mood.

So far, very few studies examined within-person associations between physical activity and depressive mood, or more broadly, affect in everyday life using intensive longitudinal designs, and these studies typically focused on samples of younger adults (e.g., Bossmann, Kanning, Koudela-Hamila, Hey, & Ebner-Priemer, 2013; Kanning & Schlicht, 2010; Langguth, Schmid, Gawrilow, & Stadler, 2016; Reichert et al., 2016; Schwerdtfeger, Eberhardt, Chmitorz, & Schaller, 2010). For example, a recent study investigated within-person associations between physical activity and affect in younger adults over 10 consecutive days (Haas, Schmid, Stadler, Reuter, & Gawrilow, 2017). Participants wore accelerometers to assess physical activity and they reported their affect before going to sleep using online diaries. The results showed that on days when participants engaged in more activity than usual, they reported not only less depressed and angry evening affect but also more vigor and serenity in the evening. Moreover, a study investigated within-person associations between physical activity in everyday life with positive and negative affect in participants aged 18 to 73 years (Schwerdtfeger, Eberhardt, & Chmitorz, 2008). Physical activity was measured throughout one day (12 hours) with accelerometers, whereas positive and negative affect were assessed every hour using handheld computer. Results showed that physical activity was significantly and positively related to positive affect but not to negative affect.

3.5.1.4 The Role of Psychological Need-Fulfillment

Several mechanisms and processes have been suggested to explain the negative association between physical activity and depressive symptoms including increases in mastery, self-efficacy, and distraction (Craft, 2005; Craft & Perna, 2004; Paluska & Schwenk, 2000) or increases in endorphin levels and reductions in cortisol levels (Johnsgard, 1989; Nabkasorn et al., 2005). One potential mechanism is psychological need-fulfillment, as engaging in physical activities may meet psychological needs, which in turn, effect depressive mood. In this study, we therefore explored the role of psychological need-fulfillment. This factor might be particularly relevant because previous research evidenced positive associations between physical activity and need-fulfillment (McDavid, Mcdonough, Blankenship, & Le-

breton, 2017), and negative associations between need-fulfillment and depression (Deci & Ryan, 1985). Further, need-fulfillment may vary as a function of changes in daily life circumstances (Patrick, Knee, Canevello, & Lonsbary, 2007). Research has shown that short-term variations in need-fulfillment and well-being were interrelated (Reis, Sheldon, Gable, Roscoe, & Ryan, 2000; Sheldon, Ryan, & Reis, 1996).

Self-Determination Theory (SDT; Deci & Ryan, 2000) has identified three essential psychological needs for optimal well-being: Relatedness, autonomy and competence. According to SDT, fulfillment of these three needs results in life satisfaction, well-being, and optimal psychological functioning. From a functional perspective, physical activity in everyday life may play an important role for all three psychological needs. First, physical activity can meet the need for competence. This psychological need represents the experience of effectiveness in one's pursuits (Deci & Ryan, 1985; Vansteenkiste, Niemiec, & Soenens, 2010). In everyday life, this may be achieved by being able to show activities of daily living such as walking to the bus stop, hiking, or gardening. Second, physical activity in everyday life can meet the need for autonomy. This psychological need reflects the desire of individuals to be the origin or source of their own behavior (Deci & Ryan, 1985) and is experienced when individuals perceive their behavior as self-endorsed (Ryan & La Guardia, 2000). This need can be satisfied when a person is able to perform daily activities based on his or her own interest. In daily life, this can be achieved when walking wherever one wants to go, when deciding or planning an activity, or when experiencing freedom to organize the day according to one's preferred structure (e.g., eating when desired, choosing among a variety of activities, freedom to structure the day individually). Third, physical activity can meet the need for relatedness. This psychological need is defined as the experience of reciprocal care and concern to important others (Deci & Ryan, 1985; Vansteenkiste et al., 2010). In daily life, participating in a walking group or going on a hiking trip with friends may meet this need. For this study, we focused on daily need-fulfillment as a composite of the three psychological needs rather than differentiating between different needs, as the basic assumption of SDT is that all three needs need to be satisfied in an individual to maintain well-being (Deci & Ryan, 2000). Given the above-mentioned considerations, one would expect that need-fulfillment explains the link between physical activity and depressive mood in daily life.

3.5.1.5 The Present Study

This intensive longitudinal study focused on within-person associations between daily depressive mood and daily physical activity in older adults across seven days. We expected that physical activity and depressive mood show day-to-day variations within individuals and are negatively interrelated. Specifically, on days when older adults engaged in more physical activity than usual, they should report less depressive mood on that day. Besides examining the relationships between daily physical activity and daily depressive mood, we explored the role of daily need-fulfillment. On the one hand, we expected that on days when older adults engaged in more physical activity than usual, they should report higher need-fulfillment on that day. On the other hand, we expected that higher need-fulfillment on a given day is associated with lower depressive mood on that day. Finally, we tested the extent to which need-fulfillment can explain the association between daily physical activity and depressive mood by means of a within-person mediation.

3.5.2 Methods

3.5.2.1 Participants

Sixty-eight healthy older adults aged 65 to 93 years (M = 78.00, SD = 7.90; 73.5% female) participated in this study. Regarding the marital status, 16.2% of the participants were single, 44.1% were married, 14.7% were divorced and 25% were widowed. Participants were recruited at the Institute of Neumuenster in Switzerland. We designed our study across seven days to have enough intraindividual data to conduct the targeted within-person analyses. During a recruitment event, potential participants had the opportunity to ask questions concerning the study and to sign up for it. Requirements to participate in this study were that the older adults had to be mobile and cognitively able to pass the mini-mental state examination (MMSE; Folstein et al., 1975). A further requirement was that participants did not need help with their daily activities from an outpatient service for home care. Regarding chronic conditions, 99% of the participants reported to be physically mobile, 9% reported to need some sort of walking frame and only 2% reported to need help from close others when performing daily activities. At the end of the study, participants received a little gift and their personal physical activity profile that has emerged from the

study.

3.5.2.2 Procedure

At the beginning of the study, participants filled out a questionnaire with demographic variables and scales that are not relevant for this study. As the sample consisted of healthy older adults, we did not extensively assess chronic conditions and somatic diseases. Research assistants visited all participants at their homes, or if desired, outside of their homes in a place at their convenience to familiarize them with the accelerometer (motion sensor) that collected daily physical activity. The intensive longitudinal part of the study took place over a period of seven consecutive days. During these days, participants carried an accelerometer to continuously record their physical activity in the form of step counts, and they reported their daily need-fulfillment and daily depressive mood and at the end of each day using a paper-and-pencil questionnaire. At the end of the study, participants were asked whether the week of data collection was a rather typical or an atypical week for them and rated this question on a scale from 1 to 10 (1 = *very atypical*, 10 = *very typical*; $M = 7.28$, $SD = 2.68$). Participants provided data on average with 6.90 measurement points of daily physical activity ($SD = 0.85$), 6.94 assessments ($SD = 0.38$) of daily need-fulfillment, and 6.93 repeated assessments ($SD = 0.40$) of daily depressive mood.

3.5.2.3 Measurements

Physical activity. An accelerometer (movisens GmbH, 2016) was used to measure physical activity objectively. This motion sensor records raw data on three-axis: Acceleration, barometric altitude and temperature (Shammas et al., 2014) with a frequency of 64 Hz. The activity output parameters in terms of daily steps were calculated using the analysis software DataAnalyzer from movisens (see www.movisens.com/en/products/dataanalyzer/). For this study, the raw data captured by the accelerometer was used to calculate the daily amount of steps as the key parameter for daily physical activity. We coded physical data with less than 1,200 steps per day as outliers to control for extreme low values of step counts (cf. Tudor-Locke et al., 2011), which resulted in 30 outliers (6.3%) out of 476 measurement points (68 participants x 7 assessments). After removing the outliers, participants provided on average 6.46 complete measurement points of daily physical activity ($SD = 1.44$).

From the 476 potential measurements of daily physical activity, there were 439 measurement points (92.2%) collected. The mean of the daily amount of steps was around 7,000 steps per day (M = 7,028.05, SD = 3,287.12) with a range from 1,468 to 15,609 steps. For reasons of comparability with the self-reports, we standardized the amount of step counts to a 1 to 10 metric for the multilevel analyses.

Daily depressive mood. Three items reflecting typical depressive mood such as hopelessness for the future, listlessness, and difficulty to start an activity from the Beck Depression Inventory (BDI; Hautzinger, Bailer, Worall, & Keller, 1994) were used to measure depressive mood. The three items are, "I feel the future is hopeless and that things cannot improve", "I was tired and listless" and "I have to force myself to any activity". The items were rated on a scale ranging from 1 (*disagree*) to 10 (*agree*). The Cronbach's α reliability estimate ranged from .68 to .78 across the seven days. Cronbach's α is a between-person measure of internal consistency. Following the recommendations of Bolger and Laurenceau (2013), we also tested for the within-person reliability. The within-person reliability estimate R_c was .70.

Daily need-fulfillment. Need-fulfillment was measured with three items from the General Causality Orientations Scale (Deci & Ryan, 1985). For reasons of parsimony, we only used one item for each need-fulfillment dimension (i.e., relatedness, competence and autonomy). The items are "Today I felt close and connected to the people I care about" (relatedness), "I felt efficient and competent in what I was doing" (competence), and "Today my actions were based on my values and interests" (autonomy). We used the average of these three items as our daily need-fulfillment score. The items were rated on a scale ranging from 1 (*disagree*) to 10 (*agree*). The Cronbach's α reliability ranged from .74 to .89 across the measurement period. The within-person reliability estimate R_c was .80.

3.5.2.4 Statistical Analysis

In this study, we investigated within-person associations between daily physical activity and daily depressive mood. In contrast to conventional longitudinal models, this intensive longitudinal study design provided multiple measurements of self-reported observations to capture within-person processes. In such designs, it is important to consider

that error terms of repeated measurements within one person are non-independent. Multilevel modeling allows the analysis of such data structure appropriately, where multiple measurements are nested within a person. Therefore, we used multilevel analysis to investigate our research questions (Bolger & Laurenceau, 2013; Kreft & DeLeeuw, 1998; Raudenbush & Bryk, 2002). With multilevel modeling, it is possible to estimate within-person processes between variables for each individual, taking into account the potentially different intercepts and slopes of each participant due to environmental and individual influences. Moreover, multilevel modeling enables researchers to differentiate within-person and between-person processes and to disentangle how variables wax and wane together within a person over multiple measurement points.

With regard to our analytical procedure, we first examined the nested structure of the data by computing intraclass correlation coefficients (ICCs) and compared how much of the total variance lied within-person. Second, we compared whether a random-intercept or a random-intercept and random-slope structure of the time-varying independent variables (daily physical activity, daily need-fulfillment, and time) best describes the data by choosing models with better goodness of fit indices (–2 log likelihood) and by comparing the χ^2-difference between two models. Third, we examined the associations between daily physical activity and daily depressive mood while controlling for the person-mean of physical activity, age, sex, and time (Model 1). Equations for the basic model examining the association between daily depressive mood and daily physical activity are depicted in the Appendix. Next, we added daily need-fulfillment to the previous model (Model 2). Finally, in Model 3 we investigated the extent to which need-fulfillment explained the association between daily physical activity and daily depressive mood using within-person mediation analysis following the procedures suggested by Bolger and Laurenceau (2013, Chap. 9). The within-person mediation analysis was conducted with bootstrapping, containing 1,000 iterations and a confidence interval of 95%.

Following Bolger and Laurenceau (2013), we included a between-person version and a within-person version of the same variable to control for the between-person effects and to truly examine the within-person variation. The between-person version of our independent time-varying predictors were the person-means. The within-person version of our independent time-varying predictors were computed by subtracting the person-mean

from the grand-mean centered variables. Age and sex (male = 0, female = 1) were grand-mean centered for the analysis. The variable time reflected the ordinal time point (day) of the daily assessments (0 to 6). We did not expect systematic mean-level changes in physical activity, need-fulfillment, and depressive mood across 7 days, as this study was not an intervention study. However, we might expect reactivity effects and individual differences over time. Therefore, we controlled for time in all our models (see Bolger & Laurenceau, 2013).

We analyzed the described models using the "lme4" package (Bates et al., 2015) in R Version 3.4.0 (R Core Team, 2017). As an indicator of effect size, the model fit was evaluated using within-person pseudo-R^2 because the exact size of R^2 cannot be computed in these types of analyses. These values represent the percentage of how much of the variance was explained by the added independent variables. As an indicator of goodness of fit we compared which models reported a lower value of the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) (Kreft & DeLeeuw, 1998; Nezlek, 2001).

3.5.3 Results

Table 13 displays the within-person descriptive statistics and correlations among the variables of interest. Results showed that daily depressive mood was negatively correlated with the daily measures of physical activity and need-fulfillment, whereas daily physical activity and daily need-fulfillment were positively interrelated. Associations with age suggest that the older participants tended to report lower levels of daily physical activity and daily need-fulfillment, and higher levels of daily depressive mood.

For the intensive longitudinal analysis, we tested whether the daily assessments of physical activity, need-fulfillment, and depressive mood were each non-independent within-person by computing intraclass correlations (ICCs). The ICC(1) describes the amount of between-person variance in regard to the total variance. The ICC(2) describes how homogenous the ratings were throughout the seven assessments within an individual (cf. Meyer et al., 2015). The amount of daily physical activity was non-independent within individuals (ICC(1) = 0.51, $F(65,373) = 7.84$, $p < .001$). This indicates that 51% of the total variance lied between-persons and 49% lied within-persons. Individuals were

distinguishable in regard to their mean level of daily physical activity (ICC(2) = 0.87). The same was true for the rating of daily depressive mood, findings showed non-independence within individuals (ICC(1) = 0.48, $F(67,403) = 7.51$, $p < .001$), and individuals were distinguishable in regard to their mean level of daily depressive mood (ICC(2) = 0.87). Also the ratings of daily need-fulfillment were non-independent within individuals (ICC(1) = 0.58, $F(67,404) = 10.42$, $p < .001$), and individuals were distinguishable in regard to their mean daily depressive mood (ICC(2) = 0.90). Therefore, we decided to analyze the data by multilevel modeling.

In examining the best structure for the time-varying predictor variables (the within-person variables of physical activity, need-fulfillment and time), we found the following results: the random-intercept model fitted the data better than the random-intercept and random-slope model for physical activity ($\Delta\chi^2 = 0.87$, $p > .05$) and time ($\Delta\chi^2 = 0.21$, $p > .05$). The random-intercept and random-slope model fitted the data better than the random-intercept model for need-fulfillment ($\Delta\chi^2 = 20.38$, $p < .001$). Following Bolger and Laurenceau (2013), we specified all time-varying predictor variables as random effects to account for additional variations.

Next, we tested Model 1 that consisted of the outcome variable daily depressive mood, the focal predictor within-person daily physical activity and the control variables person-mean of daily physical activity, age, gender, and time (Model 1, Table 14). The findings showed that daily depressive mood was negatively associated with within-person daily physical activity, meaning that an increase of one unit in physical activity was associated with a decrease of -0.14 in daily depressive mood within-person. Moreover, the results of the random effects showed that participants significantly differed in their intercepts.

In Model 2, we added the within-person variable of daily need-fulfillment and the person-mean of daily need-fulfillment to the previous model (Model 2, Table 14). The results showed that daily depressive mood was negatively associated with daily need-fulfillment, both on the within-person and the between-person level (person-mean of daily need-fulfillment). This implies that participants differed from each other but also that participants differed from themselves across the measurement occasions. In comparison to Model 1, the within-person association between daily physical activity and daily depressive mood was not statistically significant anymore. Adding daily need-fulfillment to the

Table 13: *Within-Person Descriptive Statistics and Correlations Among the Main Variables*

Variable	*M*	*SD*	1	2	3	4
1. Daily depressive mood	2.39	1.83				
2. Daily physical activity	3.39	1.70	-.20*			
3. Daily need-fulfillment	8.15	1.63	-.47*	.15*		
4. Age	78.00	7.85	.15*	-.39*	-.15*	
5. Gender	0.26	0.44	-.02	-.02	-.06	.09

Note. $N = 437$ to 471. The potential scale scores for physical activity (see method section), daily need-fulfillment, and daily depressive mood ranged from 1 to 10. Female gender was coded as 0 and male gender was coded as 1. *$p < .001$.

model attenuated the effect of daily physical activity to non-significance. The results of the random effects showed a significant variance in the within-person association between daily need-fulfillment and daily depressive mood. This implies that participants differed in the size of this association. Moreover, compared to Model 1, both AIC and BIC showed lower scores and thus indicated a better fit for Model 2. The within-person pseudo-R^2 estimate indicates more explained variance in Model 2.

Finally, in Model 3 we tested the extent to which daily need-fulfillment explained the association between daily physical activity and daily depressive mood. The results suggested that there was no significant indirect (b = -0.03, $p > .05$, 95% *CI* [-0.07, 0.00]) effect, however, the direct effect (b = -0.11, $p < .05$, 95% *CI* [-0.22, -0.01]) and total effect (b = -0.14, $p > .01$, 95% *CI* [-0.25, -0.04]) were significant. This implies that the direct association between daily physical activity and daily depressive mood was significant but not the indirect way through daily need-fulfillment.

3.5.4 Discussion

This intensive longitudinal study is one of the first examining within-person associations between physical activity, psychological need-fulfillment, and depressive mood and in daily life of healthy older adults. Summarizing the results, we found a significant negative association between daily physical activity and daily depressive mood within-persons. That is, on days when participants engaged in more physical activity than usual, they reported less depressive mood on that day. We also found that on a given day with higher need-fulfillment, participants reported less depressive mood on that day. However, in models

Table 14: *Within-Person Coupling Between Physical Activity and Depressive Mood*

	Daily depressive mood			
	Model 1		Model 2	
	Estimate	*SE*	Estimate	*SE*
Fixed Effects				
Intercept	2.52***	0.57	3.45***	0.98
Daily physical activity	-0.14*	0.06	-0.07	0.06
Daily need-fulfillment	NA	NA	-0.50***	0.08
Person-mean daily physical activity	-0.20	0.14	-0.11	0.11
Person-mean daily need-fulfillment	NA	NA	-0.62***	0.09
Age	0.01	0.02	< 0.01	0.02
Gender	0.01	0.37	-0.07	0.27
Time	< 0.01	0.03	-0.01	0.03
Random Effects				
Intercept	1.62**		1.98	
Daily physical activity	0.03		0.03	
Daily need-fulfillment	NA		0.09*	
Time	0.01		0.01	
Residuals	1.59		1.34	
AIC	1621.30		1555.35	
BIC	1674.34		1632.87	
Within-person pseudo-R^2	0.08		0.23	

Note. Number of observations = 437. Coefficients shown are unstandardized coefficients. *SE* represents the standard error of the unstandardized regression coefficients. Male gender was coded as 0, female gender as 1. Model 1 represents the model examining the association between daily physical activity and daily depressive mood. Model 2 represents the model examining the association between daily physical activity, daily need-fulfillment, and daily depressive mood. The random effect estimates were represented by random effect variances. AIC = Akaike Information Criterion. BIC = Bayesian Information Criterion. * $p < .05$. ** $p < .01$. *** $p < .001$.

containing both physical activity and need-fulfillment as predictor of depressive mood, the effect of physical activity was attenuated to non-significance. The within-person finding that daily need-fulfillment was negatively related to daily depressive mood is in line with theory and previous research (Reis et al., 2000; Sheldon et al., 1996). Generally speaking, on the one hand the present results support the claim that engaging in physical activity may be associated with reductions in depressive mood. On the other hand, the results also show clear boundary conditions of the small effect of physical activity, because daily need-fulfillment attenuated the size of physical activity to non-significance. It is possible that share method variance with respect to the assessment of need-fulfillment and depressive mood by means of self-reports was responsible, in part, for the attenuation of the effect of physical activity that was measured with a different method.

In contrast to our expectations, daily psychological need-fulfillment did not mediate the association between daily physical activity and daily depressive mood in older adults. Although the indirect effect through need-fulfillment was not significant, the direct and total effects of daily physical activity were significant. Future research should systematically test for other potential mechanisms underlying the within-person associations between physical activity and daily depressive mood in daily life. Candidates are biological factors (e.g., serotonin metabolism; Hamer, Molloy, de Oliveira, & Demakakos, 2009) or psychological factors (e.g., mastery and self-efficacy; Paluska & Schwenk, 2000). Even though psychological need-fulfillment did not function as a mechanism, a small but significant positive within-person association between physical activity and need-fulfillment was evidenced. Hence, it may be interesting to elaborate on intervention studies which address individual's need-fulfillment profile to satisfy one's individual needs through physical activity. Such daily activities could be walking groups for older adults, organized shopping trips to the mall via bikes or cooking events in the senior residence where everyone is welcome to participate for those individuals who report a high need to stay related to others in old age. Activities can address different needs and motivate to stay active due to different goals in later life. Finding an activity that is attuned to the individual need profile is likely to produce a long-term active lifestyle.

Some practical recommendations might derive from our results. First, as shown in our unobtrusive objective measurement of physical activity in daily life, lower depressive

mood was related to higher physical activity, even though physical activity was not of high intensity (i.e., walking). Accordingly, activities of high intensity are not coercively necessary to induce a better mood (cf. Bossmann et al., 2013) what might be especially important in old age, as some older adults cannot or do not want to engage in highly intensive activities such as aerobic or strength workouts. Therefore, older individuals may increase or maintain their daily number of steps to influence their mood (i.e., decrease depressive mood). Scientists and practitioners unanimously suggest that being physically active reduces negative affect and/or is positively related to positive affect, so that older adults should attempt to walk on the bright side (cf. Marselle, Irvine, & Warber, 2013; Robertson, Robertson, Jepson, & Maxwell, 2012; D. E. Rosenberg et al., 2012). The daily amount of physical activity might be increased by walking more often or longer distances (i.e., increasing the daily amounts of steps), performing everyday movements or simply getting up more often, or activities such as dancing, gardening, hiking, swimming, cycling, or household chores (cf. World Health Organization, 2017).

3.5.4.1 Strengths, Limitations and Future Research

The present study made several noteworthy contributions. First, we applied a real-life research design to assess within-person variations in physical activity, need-fulfillment, and depressive mood in contrast to earlier research with a main focus on between-person associations. Second, we used an objective measure to study the amount of physical activity, thus having a more realistic representation of how active a person in his or her everyday life is (rather than subjectively asking them how active they think they are). Furthermore, we preferred to capture physical activity as it occurs in daily life compared to artificially forming groups that may not adequately represent how active individuals are in their everyday life.

Despite these strengths, several limitations must be noted. First, the study period included seven consecutive days. Although we are convinced that one week of assessment gave us some idea about the associations between the examined processes, it cannot be excluded that seven days are not enough to get a more valid picture of everyday life of older people. Future studies should assess a higher number of participants and cover a longer assessment period that may provide more information about the unfolding processes and

its associations over several weeks. Second, participants responded to self-report questions only at the end of each day. Higher frequency of assessments per day (e.g., morning and evening or even more often) would have given a more fine-grained picture of how these associations unfold in everyday life. For instance, it would be interesting to investigate whether physical activity and depressive mood, respectively, in the morning are associated with depressive mood and physical activity, respectively, in the evening. Future research should investigate potential time lagged effects and circadian patters. Moreover, not only time triggered assessments should be applied, but also activity triggered assessments. This means that participants would report on their mood if a certain activity threshold is reached. Third, we did only use three items to assess need-fulfillment. Future studies may want to use more items to capture the needs of autonomy, competence and relatedness in greater detail. It would be interesting to determine how these subscales are differentially related to daily depressive mood.

Finally, in our multilevel models we have only looked at one direction, that is, from physical activity to depressive mood. However, it is also possible, that lower depressive mood might lead to higher physical activity. Future studies with more measurement occasions and a higher number of participants might disentangle the bidirectional relationship of physical activity and depressive mood. We assume that both vicious and positive circles within individuals can unfold bi-directionally for physical activity and depressive mood. These circles are likely to be strongly reinforcing in one's normal everyday life. For example, by starting to be more physically active, people possibly become less depressed and feel motivated and encouraged to being physically active in the future. By going out and experience small but effective results from their physical activity on the social, on the physical, and on the psychological level, these benefits might change the negative mindset and reduce depressive symptoms on an active day. The lowered depressive mood of that day, in turn, can reduce burdens to start being active again (e.g., motivation to start, self-confidence to go out, general energy level, more positive thinking patterns). On the other hand, by reducing physical activity and increasingly staying at home, people might be stuck in a vicious circle of lower energy, more depressive mood, lower self-confidence, and less courage to go out and be active that further reduces their motivation to engage in physical activity.

3.5.4.2 Conclusions

There are two main conclusions to this study. First, the results provide support for negative within-person associations between objectively assessed daily physical activity and daily self-reported depressive mood in older adults. Second, the results also demonstrate the limits of daily physical activity for daily depressive mood in old age, and emphasize the role of daily need-fulfillment as an important resource for healthy functioning. Future studies are needed to better understand how, when, and why different types of physical activities (not only the amount of daily steps) prevent or reduce depressive mood. Overall, this study adds additional evidence to the associations between physical activities and depressive mood on the within-person level in daily life of older adults.

3.5.4.3 Author Contribution

Marko Katana wrote the methods and results section of this manuscript and analyzed the data. Damaris Aschwanden wrote the introduction and discussion section of this manuscript. All remaining others provided feedback on the manuscript.

Chapter 4

General Discussion

Subjective well-being has been defined as a core outcome of healthy aging (World Health Organization, 2015). This dissertation aimed at describing and understanding real-world variability in affect as one important indicator of subjective well-being. For this purpose, the affect variability in everyday life (AVEL) framework was conceptualized and tested in six studies. The key assumptions of the AVEL framework posit that everyday life affect as well as its fluctuations are mainly linked to three aspects: individual differences, intraindividual differences, and choice of timescale of assessment. First, everyday life affect is expected to be associated with stable individual differences. Past research has identified personality traits to be related to daily affect (Mroczek & Almeida, 2004). In research question 1, a specific individual trait characteristic, which has been shown to be related to aging processes, namely trait forgivingness, was investigated in more detail. Second, the AVEL framework posits that everyday life affect does not only depend on individual differences but also on intraindividual fluctuations in concert with covariates of affect. Most prominently, situational changes such as event occurrences or stressors are known to co-vary with the ebb and flow of affect in everyday life (Stawski et al., 2019). Research questions 2 and 3 aimed at extending Rowe and Kahn's (1997) model of successful aging that considers cognitive and physical functioning to be key components of positive aging outcomes such as well-being. To this day, little is known about how cognitive and physical functioning co-vary within individuals in everyday life. Further, there is no consensus on how to measure cognition outside the laboratory appropriately. This research used cognitive reflection processes, such as thinking about the future and cognitive reappraisal

as proxies of real-world cognition (research question 2). Physical functioning was also assessed by two proxies, namely experiences of physical pain and an objective way of measuring physical activity (research question 3). Third, the AVEL framework posits that the interpretation of variability in affect depends on the timescale applied to measure ups and downs in affect. Traditionally, research has distinguished between micro-longitudinal variability and macro-longitudinal change (Ram & Gerstorf, 2009). However, little is known about the functionality of affect variability over different time intervals when zooming in on micro-longitudinal studies (Röcke & Brose, 2013). Research question 4 specifically examined the potential differences in the interpretation of results which might arise when applying retrospective daily diary questionnaires versus momentary experience sampling approaches.

4.1 Summary of Empirical Results

Research Question 1: How are Individual Trait Differences Associated with the Manifestation of Affect in Everyday Life?

To answer the first research question, trait forgivingness was used in article 1 as an aging related example of individual differences. More specifically, article 1 ($N = 332$) investigated whether trait forgivingness was associated with trait affect as well as daily affect and whether these associations differed across adulthood. Chronological age was used as a between-person moderator to address this question. Participants (18 to 77 years, $M = 45.5$) completed baseline measures of forgivingness, positive affect and negative affect along with daily assessments of positive and negative affect for up to 10 days. The results showed that trait forgivingness was associated with less negative affect and more positive affect at the trait and state level. However, forgivingness was no longer associated with daily affect when controlling for chronological age. Nevertheless, a moderation between forgivingness and chronological age showed that the negative association between forgivingness and negative affect (both trait and state) was more pronounced in older adults than in younger adults. Therefore, research question 1 can only be partly answered by trait forgivingness as an individual differences characteristic associated with affect in everyday life.

Research Question 2: How does Affect Co-Vary with Cognitive Reflection Processes in Everyday Life?

To address the second research question, two proxies of cognitive reflection processes in everyday life were examined: the perception of the future and the use of cognitive reappraisal as an emotion regulation strategy. Article 2 focused on the within-person coupling between future time perspective and affect, while article 3 focused on the within-person coupling between emotion regulation and affect in everyday life. In article 2, two studies investigated whether everyday life future time perspective co-varied with everyday life affect and examined age differences in these within-person couplings. Study 1 (N = 564) used data from a daily diary study over 10 days with a wide age range across the adult lifespan (20 to 75 years, M = 48.30). Study 2 (N = 136) used data from an experience sampling study over 10 days obtained from healthy older adults (60 to 91 years, M = 70.45). Multilevel modeling showed that days and moments with a more open-ended future time perspective were also days and moments with more positive affect, more energetic arousal, more calmness, more positive valence, and less negative affect. Moreover, older adults, as opposed to younger adults, showed a weaker within-person coupling between future time perspective and positive affect, negative affect, and energetic arousal. These differential findings were more pronounced in the adult lifespan sample that ranged from 20 to 75 years of age than in the sample of older adults with a more restrictive age range from 60 to 91 years.

Article 3 (N = 89) examined the within-person coupling between cognitive reappraisal and affect in the daily lives of geriatric nurses. Participants (17 to 60 years, M = 43.48) rated their daily affect and use of cognitive reappraisal over the course of 21 days. At the within-person level, cognitive reappraisal was positively associated with higher positive and lower negative affect. This is in line with the assumption that individuals who habitually use cognitive reappraisal experience higher subjective well-being because the key function of reappraisal is to diminish negative emotions (Hu et al., 2014). This finding was extended to the daily lives of a specific sample of geriatric nurses who are likely to be confronted with emotionally taxing work conditions. Research question 2 can be answered by showing that affect positively co-vary with cognitive reflection processes within individuals in everyday life.

Research Question 3: How does Affect Co-Vary with Physical Functioning in Everyday Life Affect?

To address the third research question, two articles examined aspects of physical functioning in terms of physical pain and physical activity in everyday life. Article 4 focused on the within-person coupling between pain and affect. Article 5 focused on the within-person coupling between physical activity and affect. In article 4 ($N = 224$), participants (63 to 93, $M = 77.60$) reported on their daily experience of pain, impairment by their pain, and affect during 21 consecutive days. Multilevel modeling results showed that on days with increased pain, individuals also reported less positive affect and more negative affect. Time-lagged results indicated a temporal carry-over from yesterday's pain to today's negative affect but not to today's positive affect. Moreover, on days when individuals reported to feel more strongly impaired by their pain, they showed a stronger within-person association between daily pain and affect in contrast to days with a weaker experience of daily impairment.

Article 5 ($N = 68$) examined the within-person association between physical activity and depressive mood in older adults (65 to 93 years, $M = 78.00$) across 7 days. Physical activity was objectively assessed with accelerometers, whereas depressive mood was assessed using self-reports at the end of each day. The study also tested whether days with higher self-reported need-fulfillment (competence, autonomy and relatedness) helped older individuals to dampen the association between physical activity and depressive mood. Results from multilevel analyses showed that daily physical activity was negatively related to daily depressive mood within individuals. Results further showed that daily need-fulfillment was also negatively related to daily depressive mood. However, daily need-fulfillment did not moderate the association between physical activity and daily depressive mood. Research question 3 can be answered by showing that affect positively co-varies with physical functioning within individuals in everyday life.

Research Question 4: What are the Implications of Study Design Differences on the Interpretation of Results When Measuring Affect on Different Timescales?

To reduce participants' burden, this research used very short everyday life measures of affect. Most of this research relied on end-of-day reports regarding daily affect. It is possible that such reports reflect (a) the strongest feelings that individuals had during a day, (b)

how they were feeling at the end of the day or (c) how they were feeling when they provided the ratings (e.g., Röcke et al., 2011). To truly capture intraindividual variability in affect, study designs should apply an experience sampling approach by using questionnaires on participants' smartphones, asking participants to rate their momentary affect. Depending on the variable observed, the length of the study and the frequency of assessments are crucial to capture dynamic processes. Too small intervals between assessments might lead to the misperception of stability, while sampling with too large intervals might miss the actual fluctuation (Boker & Nesselroade, 2002; Ram & Gerstorf, 2009). For the assessment of affect, a higher frequency per day (e.g., morning and evening or more) could give a more fine-grained picture of how the examined within-person couplings unfold in everyday life. For example, such studies would make it possible to investigate whether early morning affect is associated with affect in the afternoon or in the evening, taking circadian patterns into account. High-frequency assessments of affect allow to use time-structured approaches to model processes in everyday life in more detail than mere amplitudes of fluctuations as net variability approaches do (Röcke & Brose, 2013). For example, zooming in on a micro timescale would allow to study the duration of an emotional episode or the temporal return to the individual's usual affect (Kuppens et al., 2010).

Research question 4 can be answered by looking at the adaptivity of variability in affect when applying different timescales of assessment. On the one hand, stability in affect over multiple days is seen as a sign of intact psychological functioning (Gruber, Kogan, Quoidbach, & Mauss, 2013). On the other hand, variability on a shorter timescale (i.e., momentary assessment) is seen as adaptive when looking at event occurrences during the day (Kashdan & Rottenberg, 2010). Therefore, the interpretation of the adaptivity of (in)stability of affect highly depends on the timescale that was chosen to be investigated (Röcke et al., 2018).

4.2 Limitations and Future Directions

Future work on extending the AVEL framework and testing its assumptions should consider a number of promising directions. First, more valid and reliable self-report measurements to assess affect and especially covariates of affect (e.g., cognitive and physical

functioning) on short timescales are needed. Second, to fully test the potential of the AVEL framework, context should be assessed in a continuous and more objective way with the help of new technologies such as additional wearable sensors. Third, the AVEL framework's assumptions only focus on healthy adults and not on individuals with illness or strong impairments. Future research should link AVEL's short-term variability in affect to long-term outcomes that can determine differential health trajectories such as intrinsic capacities and functional ability.

4.2.1 Self-Reports in Everyday Life Research

The empirical studies in this dissertation used mainly paper-and-pencil diaries or questionnaires presented on smartphones. Even though many studies are conducted via smartphones or other portable devices, aging research with regard to variability in affect still often applies paper-and-pencil questionnaires for reasons of feasibility for older participants. There are reasons to believe that older adults feel more comfortable in participating in a paper-and-pencil study than in a smartphone study (Cajita, Hodgson, Budhathoki, & Han, 2017). One limitation of paper-and-pencil diaries, compared to smartphones, is that they do not offer objective time stamp information on when the diary questionnaires were actually filled in. In those studies, older adults are typically asked to complete their daily diary every evening and are instructed not to postpone it to the next day. Older adults are likely to follow these instructions as they are more conscientious with regard to study adherence than younger adults (Park et al., 1999; B. W. Roberts & Mroczek, 2008). Even though paper-and-pencil designs are better suited for the current cohort of older participants, they do not sufficiently capture momentary fluctuations. A recent study conducted in Switzerland supports the idea that the use of smartphone-based studies will also find acceptance among older participants. It showed that 43% of older adults used one or more mobile devices and that 57% of those are willing to share their data for research purposes (Seifert, Hofer, & Allemand, 2018).

Researchers may wish to consider developing scales that are better able to capture daily fluctuations (see Zimmermann et al., 2019). Even though the PANAS is a valid and reliable construct that can assess stable individual differences (Watson et al., 1988), it is questionable whether such a lengthy questionnaire is suited for everyday life research

(Brose, Schmiedek, Gerstorf, & Voelkle, 2019). As of yet, no consensus exists with regard to which items should be used to measure affect fluctuation on a micro timescale. When it comes to cognitive processes, there is even less consensus about appropriate self-report measurement that can be applied in an ecologically valid way outside the laboratory. Cognitive complaints in the form of the Nuremberg Self-Assessment List (Oswald & Fleischmann, 1995) were used in previous everyday life studies (Aschwanden et al., 2018). The list of items consists of questions such as "I had difficulties to focus on a task or to follow a conversation", "I misplaced or lost an object (e.g., keys, glasses)", "I had difficulties to remember a name" or "I forgot something (e.g., birthday, grocery item, medication)". Future research aiming at assessing everyday life processes should focus on creating reliable self-report measures that can be assessed on smartphones and, by doing so, reduce the burden for participants.

Above and beyond using self-reports to assess processes in everyday life, the emergence of new technologies offers the possibility to measure affective functioning in alternative ways. A promising direction is the use of chatbots that can ask individually tailored questions and give advice to the participants (Stieger et al., 2018). Conversational agent-based coaching could be used to plan future studies aiming at improving participants' well-being. For example, if individuals subjectively suffer from too high or too low variability in their everyday affect, the use of such chatbots could be helpful to change one's experience of affect. Future intervention studies need to test whether affect states can be intentionally changed by smartphone coaches.

4.2.2 Assessing Context

Testing the AVEL framework as a whole requires taking a lot of contextual information into account while studying intraindividual variability in affect. Assessing context leads to a better and more ecologically valid understanding of affective processes. Typical contextual information is data on the participant's whereabouts or data on interaction partners. To measure contextual information, the application of wearable sensors is likely to be a fruitful tool for future research (for a review, see Harari et al., 2017). Global positioning system (GPS) sensors allow to investigate mobility indicators such as different types of transportation modes and the travel duration distinguished by passive and active

transportation modes (Fillekes, Röcke, Katana, & Weibel, 2019). Electronically activated recorders (EAR) can be used to record small snippets of everyday life speech and encode how much individuals talk about the past, the present, or the future (Demiray, Mehl, & Martin, 2018). This approach could be particularly useful when planning future studies examining social cognition (e.g., thinking about the future together with a partner) in association with affect. Bluetooth sensors can be applied to measure the connectivity between individuals (Chen et al., 2014). In this vein, studies that examine social interaction between individuals can measure proximity and frequency of social contact in a more objective way than traditional self-report. Notably, these technological approaches are an important addition to self-report, but they cannot measure the subjective interpretation of an individual's mobility patterns, conversations, or social interactions.

Context can be assessed in everyday life following either the time-contingent or the event-contingent sampling approach. The event-contingent sampling approach allows one to tailor the assessment of affect to the contextual change of interest in the specific research question. In time-contingent sampling, the fluctuations in affect might be missed due to inappropriate time intervals. All studies in this dissertation used a time-contingent sampling approach independent of the particular physical and social context of the participant. This means that affect was assessed in fixed time intervals (i.e., once a day) or in random time intervals across the day (i.e., three times a day). Future research that wants to focus more strongly on everyday life contexts of the participants may want to choose an event-contingent sampling approach based on sensor-data as described above (Wrzus & Mehl, 2015). For example, smartphone questionnaires could be triggered by occasions such as being at a certain location or interacting with a specific person.

4.2.3 From Short-Term Variability in Affect to Long-Term Well-Being

This dissertation examined affective short-term processes in everyday life and did not investigate long-term consequences of intraindividual variability in affect. Future research should examine the link between short-term variability and long-term change in order to better understand developmental processes and health outcomes. For example, does

daily variability in positive affect predict stability in subjective well-being over the years? One recent theoretical model from research on personality change posits that long-term personality development occurs due to repeated short-term, situational processes. Along similar lines, repeated triggering situations, expectancy, states/state expressions and reactions (TESSERA) can shape trait affect over the long-term (Wrzus & Roberts, 2017). The TESSERA model offers a conceptual framework that links short- and long-term processes by addressing different timescales of measurement. For example, when an individual experiences situational perturbation of affect in daily life in a repeated manner, these events shape the expectancy of affect regulation. In turn, when these fluctuations in the manifestation of state affect occur repeatedly in everyday life, it can lead to changes in trait affect in the long term. Therefore, intentional change can be targeted at different timescales such as the state level, the habits level or the trait level (Allemand & Flückiger, 2017).

The investigation of different timescales can be examined by measurement-burst designs (Nesselroade & Schmidt McCollam, 2000; Sliwinski, 2008). Such study designs obtain data over multiple bursts over a long period of time (e.g., years), each burst containing measurements of shorter time intervals (e.g., days). Considering that long-term change can be well measured in the laboratory (Schaie, Willis, & Pennak, 2005), future studies aiming at applying a measurement-burst design to assess both short-term variability and long-term change should think about combining traditional laboratory and everyday life assessments.

4.3 Implications and Conclusion

This dissertation has three main implications. The first implication is theoretical. A framework of affect variability in everyday life (AVEL) was conceptualized. In contrast to previous models of subjective well-being (Diener et al., 1999) and successful aging (Rowe & Kahn, 1997), the AVEL framework incorporates a more dynamic everyday life perspective to better understand affective processes. This point of view should foster new theoretical thinking about intraindividual variability in affect and empower the construction of future theoretical models. The second implication of this dissertation is methodological. It comes from differentiating between different assessment approaches of studying affect

in everyday life. Researchers should think about the appropriate timescale of measuring affect for addressing their specific research questions. New statistical tools such as dynamic system modeling (Boker & Martin, 2018) can help with examining affect at different methodological levels. The third implication is practical. A more in-depth understanding of intraindividual variability of affect should help developing individually tailored interventions to maintain high levels of affect across the lifespan and in old age.

In sum, this dissertation answered four research questions based on the assumptions of the AVEL framework. First, the intensity of everyday life affect is associated with individual differences. Second, intraindividual variability in affect is positively associated with cognitive reflection processes such as future time perception and cognitive reappraisal. Third, intraindividual variability in affect is positively associated with physical functioning measured by physical pain and physical activity levels. Fourth, functional interpretation of (in)stability of affect depends on the interval of assessment chosen in the study design. On the one hand, stability of affect over multiple days is a sign of intact psychological functioning. On the other hand, variability in affect can be adaptive over short timescales (such as moments) when adjusting to situational change. This thesis makes a significant contribution to the aging research by looking at manifestations of everyday life affect in considerable detail.

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sonality assessment: First steps toward the development and validation of a personality dynamics diary. *Psychological Assessment*, *31*, 516–531. doi: 10.1037/pas0000625.supp

Curriculum Vitae

Education

08/2016 – 06/2019 PhD studies in Psychology, University of Zurich

08/2016 – 06/2019 International Max Planck Research School on the Life Course

08/2013 – 08/2016 Master of Science in Psychology, University of Zurich

08/2009 – 08/2013 Bachelor of Science in Psychology, University of Zurich

Research Visits

04/2018 – 05/2018 Stanford University, Stanford, USA

01/2017 – 02/2017 Washington University, St. Louis, USA

Peer-Reviewed Publications

Katana, M., Hill, P., & Allemand, M. (2019). Variability in daily future time perspective and affect across adulthood and old age: Two intensive longitudinal studies. Submitted to *Journal of Personality*.

Katana, M., Röcke, C., & Allemand, M. (2019). Intra- and interindividual differences in the within-person association between daily physical pain and affect of healthy older adults. Submitted to *Journal of Behavioral Medicine*.

Katana, M., Röcke, C., Spain, S. M. & Allemand, M. (2019). Emotion regulation, subjective well-being, and perceived stress in daily life of geriatric nurses. *Frontiers in Psychology*, *10*, 1-11. doi:10.3389/fpsyg.2019.01097

Katana, M., & Hill, P. (2019). Emotional aging on different time-scales. In P. L. Hill & M. Allemand (Eds.), *Personality and healthy aging.* New York, NY: Springer (submitted manuscript).

Kroencke, L., Harari, G. M., **Katana, M.**, & Gosling, S. D. (2019) Personality trait predictors and mental well-being correlates of exercise frequency across the academic semester. Accepted for publication in *Social Science & Medicine.*

Fillekes, M., Röcke, C., **Katana, M.**, Weibel, R. (2018). Self-reported versus GPS-derived indicators of daily mobility in a sample healthy aging research. *Social Science & Medicine*, *220*, 193-202. doi: 10.1016/J.SOCSCIMED.2018.11.010

Hill, P. L., **Katana, M.,** & Allemand, M. (2018). Investigating the affective signature of forgivingness across the adult years. *Research in Human Development*, *15*, 21-32. doi: 10.1080/15427609.2017.1414526

Gruenenfelder-Steiger, A. E., **Katana, M.,** Martin, A. A., Aschwanden, D., Koska, J. L., Kuendig, Y., Allemand, M. (2017). Physical activity and depressive mood in the daily life of older adults. *GeroPsych*, *30*, 119-129. doi: 10.1024/1662-9647/a000172

Presented Talks

Katana, M., Hill, P., & Allemand, M. (2019, May). *Short-term variability of future time perspective.* Talk presented at the 9^{th} International Association of Gerontology and Geriatrics European Congress, Gothenburg, Sweden.

Katana, M., Hill, P., & Allemand, M. (2019, April). *Variability of future time perspective in everyday life.* Talk presented at the 3^{rd} World Conference on Personality, Hanoi, Vietnam.

Katana, M., Röcke, C., & Allemand, M. (2018, July). *Daily affect and non-exercise physical activity in old age.* Talk presented at the 19^{th} European Conference on Personality, Zadar, Croatia.

Katana, M., Röcke, C., & Allemand, M. (2017, October). *Affective reactivity to daily uplifts and hassles of healthy older adults.* Talk presented at the LIFE Fall Academy, Zurich, Switzerland.

Katana, M., Fillekes, M., & Röcke, C. (2017, September). *Using accelerometer and GPS data to measure physical activity and mobility, and its relation to daily affect.* Symposium presented at the 15^{th} Conference of the Swiss Psychological Society, Lausanne, Switzerland.

Röcke, C., **Katana, M.**, Weibel, R., Martin, M., Allemand, M. (2017, September). *Aktivitäten, Affekt und Stress im Alltag älterer Menschen: Das MOASIS Projekt.* Symposium presented at the Gemeinsame Tagung der Fachgruppen Entwicklungspsychologie und Pädagogische Psychologie, Münster, Germany.

Katana, M, Röcke, C., Martin, M., Jäncke, L., Allemand, M. (2017, June). *Within-person association between physical activity and affect of healthy older adults.* Symposium presented at the 5^{th} Biennial Conference of Society for Ambulatory Assessment, Luxembourg, Luxembourg.

Katana, M., Hill, P., & Allemand, M. (2017, February). *Cross-sectional and longitudinal analysis of the relationship between affect and forgiveness.* Talk presented at the Washington University in St. Louis, St. Louis, Missouri, USA.

Presented Posters

Katana, M., Hill, P., & Allemand, M. (2019, April). *Daily future time perspective and affect in everyday life.* Poster presented at the 5^{th} Conference of Aging & Cognition, Zurich, Switzerland.

Röcke, C., **Katana, M**., Fillekes, M., Mike, M., & Weibel, R. (2018, November). *Mobility, activity and social interaction in the daily lives of healthy older adults: Study protocol of the MOASIS project.* Poster presented at the Gerontological Society of America 2018, Boston, Massachusetts, USA.

Katana, M., Patrick, P., & Allemand, M. (2018, October*). Short-term variability of future time perspective.* Poster presented at the LIFE Fall Academy 2018, Charlottesville, Virginia, USA.

Katana, M., Röcke, C., & Allemand. M. (2018, June). *Dynamics of daily affect and non-exercise physical activity in healthy older adults: Findings from the mobility, activity and social interaction study.* Poster presented at the 11^{th} Schweizer Gesellschaft für Gerontologie, Montreux, Switzerland.

Katana, M., Allemand, M., & Röcke, C. (2018, May). *What are meaningful features of accelerometer data?* Poster presented at the LIFE Spring Academy 2018, Berlin, Switzerland.

Katana, M., Röcke, C., & Allemand. M. (2018, April). *Within-person associations between daily physical activity and affect in older adults.* Poster presented at the 5^{th} Society of Social Science Conference, Los Angeles, California, USA.

Katana, M., Röcke, C., & Allemand, M. (2017, May). *Study protocol: Mobility, activity and social interaction study (MOASIS).* Poster presented at the LIFE Spring Academy, Ann Arbor, Michigan, USA.

Katana, M., Röcke, C., & Allemand, M. (2017, April). *Within-person association of daily mood and daily self-reported health in older adults.* Poster presented at the 3^{rd} Conference of Aging & Cognition, Zurich, Switzerland.